RADIO FREQUENCY RADIATION TEST SET

Model 8700 Series
OPERATION AND MAINTENANCE MANUAL

narda
A Subsidiary of LORAL

OWNER'S RECORD

Meter Model # _____

S/N _____ Calibration Date _____

Probe Model # _____

S/N _____ Calibration Date _____

Probe Model # _____

S/N _____ Calibration Date _____

Probe Model # _____

S/N _____ Calibration Date _____

Probe Model # _____

S/N _____ Calibration Date _____

TECHNICAL MANUAL
OPERATION AND MAINTENANCE INSTRUCTIONS
FOR
RADIO FREQUENCY RADIATION TEST SET
8700 SERIES

U.S. Patent Nos.
3641439, 4518912, 4023093,
4629978, 4634968
Des. 280, 388,
4611166, 4605905
additional Foreign Patents

THE NARDA MICROWAVE CORPORATION

10/91 LCI 500

8700 Series

WARNING

ELECTROMAGNETIC RADIATION

USER MAY BE EXPOSED TO POTENTIALLY HAZARDOUS ELECTROMAGNETIC RADIATION DURING OPERATION. REVIEW AND ADHERE TO ALL SAFETY PROCEDURES.

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SECTION I

INTRODUCTION

1-1. GENERAL. This manual contains information regarding the operation and maintenance of the Radio Frequency Radiation Test Set, comprising of Model 8716 or Model 8711 meter, and one or more 8700 Series Probes, hereinafter referred to as Test Set (see Figure 1-1). Section I, Introduction, contains general information relating to the use of the

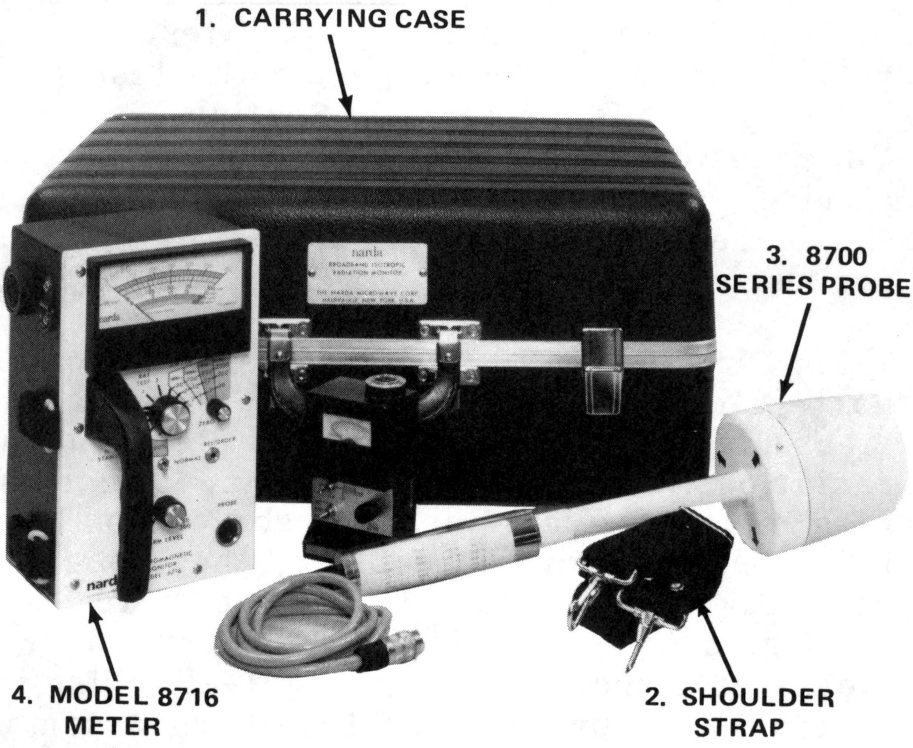


Figure 1-1. Model 8700 Radio Frequency Radiation Test Set

manual, describes the purpose and use of the test set, and lists the tabulated data pertinent to the test set. Section II contains instructions for preparing the test set for use. A general Theory of operation of the test set is contained in Section III. Section IV contains instructions for evaluating radiation sources, safety precautions to be observed when taking measurements, and detailed information relating to the controls and indicators of the test set. Also included are procedures for startup, normal operation, operation under abnormal conditions and shut-down. Procedures for maintaining the test set are contained in Section V. Section VI contains information for calibration and alignment of the test set. Information for preparing the test set for shipment is provided in Section VII. Section VIII contains information for storing the test set. Section IX contains a list of replacement parts for the meters and probes.

1-2. DESCRIPTION. The test set is a portable, battery-operated instrument for detecting and measuring potentially hazardous electromagnetic radiation from .3 MHz to 40 GHz. It consists of a meter assembly and a probe assembly interconnected by the cable of the probe assembly. (See Figure 1-2.) The meter may be hand-held or for the Model 8716 carried by means of a shoulder strap. Self-clinching fasteners are provided on the meter assembly to secure the probe while transporting the unit

out of the carrying case, during climbing or for one-hand operation. A carrying case is provided to protect the test set when not in use and for transporting the test set. A list of equipment supplied is contained in Table 1-1. The technical and physical characteristics of the test set are listed in Table 1-2.

The probe assembly detects electromagnetic radiation and transmits a signal to the meter assembly. The meter assembly processes the signals from the probe assembly to provide a display of the radiation level on the built-in meter. The meter display is calibrated to show the percentage of ANSI C95.1-1982 Radiation protection Guide from 0.3 to 300 percent with Model 8722 probes, or mW/cm^2 with other 8700 series probes. The meter assembly includes built-in test capability for testing the condition of the battery charge as well as checking and adjusting the zero-setting and functioning of the probe assembly.

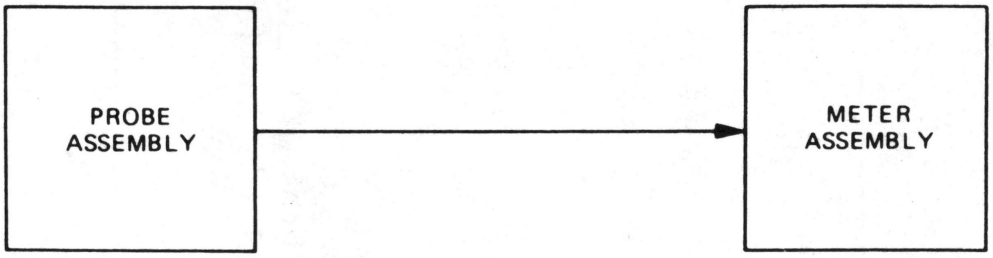


Figure 1-2. Radio Frequency Radiation Test Set Simplified Block Diagram

Table 1-1

List of Equipment Supplied

Nomenclature	Common Name	Part No.	Function
Carrying Case	Carrying Case	10666808	Houses test set when not in use and provides shielding from stray RF radiation.
Shoulder Strap	Shoulder Strap	99902000	Provides a convenient, safe method of carrying test set meter assembly.
Probe, Radio Frequency Radiation Test Set	Probe Assembly	(87XX)	Detects electromagnetic radiation for display by meter.

Table 1-1 (Cont)

Nomenclature	Common Name	Part No.	Function
Meter, Radio Frequency Radiation Test Set	Meter Assembly	8711 or 8716	Provides a display of electromagnetic radiation sensed by the probe.
Technical Manual	Technical Manual		Provides technical documentation for operating and maintaining the test set.
Battery*	Battery	88009000 (8711) NEDA 1604	To provide operating power (one required).

*Model 8716 contains 2 internal NiCad batteries (P/N 88018000)

Table 1-2

Leading Particulars

Item	Technical characteristics
METER, Model 8711	
Dynamic Range	30 dB
Scale	3-10 dB full scale ranges: 3, 30, and 300% (with model 8722) Multiple mW/cm^2 scales for use with other 8700 series probes
Meter	D'Arsonval Type, 1 1/2 inch scale
Instrument Accuracy	$\pm$3%
Response Time (approximate)	1 second; 3 seconds most sensitive scale
Zero Control	
Type	Continuous automatic zeroing in effect during all measurements.
Offset	.1%/C^o typical

Table 1-2 (Cont)

Item	Technical characteristics
METER, Model 8711	
Battery	
Battery Type	One 9 volt, NEDA 1604 Disposable
Battery Life	150 hours minimum (200 hours typical at 2 hr/day rate
Size	
Meter Dimensions	1.75 x 4.62 x 2.62 inches
Weight	
Meter	1.0 lb
METER, Model 8716	
Dynamic Range	30 dB
Scale	3-10 dB full scale ranges: 3, 30, and 300% (with Model 8722), Multiple mW/cm2 scales for use with other 8700 series probes
Meter	D'Arsonval Type, 4 1/2 inch scale

Table 1-2 (Cont)

Item	Technical characteristics
METER, Model 8716	
Instrument Accuracy	±3%
Response Time (approximate)	1 second; 3 seconds most sensitive scale
Zero Control	
Type	Continuous automatic zeroing in effect during built-in test and all measurements.
Offset	.1%/C° typical
Maximum Hold Mode	Displays maximum average exposure level that is detected after being placed in the maximum hold mode
Battery	
Battery Type	Two 9 volt, NiCad Rechargeable
Battery Life	30 hours use (2:1 use to charge ratio)

Table 1-2 (Cont)

Item	Technical characteristics
METER, Model 8716	
Battery Test	Independent test of each battery with minimum battery condition mark provided on the meter scale
Self Test	
Number of Signals	2
Frequencies	12 GHz (radiated); 10 kHz (conducted)
Testability	Independent functional performance confirmation of each field sensitive element, and overall test of supporting electronics
Additional Features	Front Panel Adjustable Alarm
Recorder Output	+3V at full scale into minimum load resistance of 1000 ohms

Table 1-2 (Cont)

Item	Technical characteristics
METER, Model 8716	
Size	
Meter Dimensions	9.62 x 5.62 x 4.50 inches
Carrying Case Dimensions	18 x 14.75 x 8.50 inches
Weight	
Meter	4.4 lbs
Carrying Case	9.4 lbs
OVERALL SYSTEM SPECIFICATIONS	
Temperature	
Operating	-10°C to +50°C
Non-Operating	-55°C to +75°C

Table 1-2 (continued)

BROADBAND ISOTROPIC PROBES

Probe Model	8762	8761	8760	8721	8723	8752	8754	8731	8733
Type	ELECTRIC FIELD					MAGNETIC FIELD			
Freq. Ranges	300 kHz to 1 GHz			300 MHz to 40 GHz		0.3 to 10 MHz		10 MHz to 300 MHz	
Power Ranges Full Scale (Equivalent Power Density)	2 20 mW/cm^2 200	.2 2 mW/cm^2 20	.2 μW/cm^2 2 μW/cm^2 20 μW/cm^2	0.2 2 mW/cm^2 20	1 10 mW/cm^2 100	2 20 mW/cm^2 200	20 200 mW/cm^2 2000	0.2 2 mW/cm^2 20	1 10 mW/cm^2 100
Field Strength Full Scale (Mean Squared Field Strength)	8000 V^2/m^2 80,000 800,000	800 V^2/m^2 8,000 80,000	.800 V^2/m^2 8.0 80.0	800 V^2/m^2 8,000 80,000	3800 V^2/m^2 38,000 380,000	.05 A^2/m^2 .5 5.0	.5 A^2/m^2 5 50	.005 A^2/m^2 .05 .5	.026 A^2/m^2 .26 2.6
Accuracy of Probe Calibration at Test Frequencies	±0.5 dB								
Isotropic Response	±.5 dB			±1 dB		±.5 dB			
Freq. Sensitivity .3 to 10 MHz	–	–	–	–	–	±0.5 dB		–	–
3 to 300 MHz	±1 dB			–	–	–		–	–
10-300 MHz	–	–	–	–	–	–		2 dB Max Total Deviation	
13-200 MHz	–	–	–	–	–	–		±0.5 dB	
.3-1000 MHz	±2 dB			–	–	–		–	
1-40 GHz	–	–	–	±1.25 dB		–		–	–
.85-16 GHz	–	–	–	+0.75/-1 dB		–		–	–
.3 to 40 GHz	–	–	–	+1.25/-3 dB		–		–	–
CW Overload*	600 mW/cm^2	60 mW/cm^2	10 mW/cm^2	300 mW/cm^2	1000 mW/cm^2	600 mW/cm^2	6 W/cm^2	60 mW/cm^2	300 mW/cm^2
Peak Power*	600 W/cm^2	60 W/cm^2	10 W/cm^2	60 W/cm^2	300 W/cm^2	600 W/cm^2	1 kW/cm^2	20 W/cm^2	300 W/cm^2
Calibration Frequencies	0.3, 0.5, 1.0, 3.0, 13.56, 27.12, 40.68, 100, 200, 300, 750, 1000 MHz			0.3, 1.7, 2.45, 4.0, 5.0, 6.0, 7.0, 8.2, 9.3, 10, 11, 18, 26, 40 GHz		0.3, 0.5, 1, 3, 10 MHz		10, 13.56, 27.12, 40.68, 50, 75, 100, 150, 200, 250, 300 MHz	
Size Probe	17 3/4" (45 cm) Long Including 4" Cup			13" (33 cm) Long Including 2 1/8" Sphere		17 1/4" (43.8 cm) Long Including 4" Cup		16 1/2" (41.9 cm) Long Including 3 1/2" Dia. Sphere	
Cable	Four Feet Long (123 cm)								
High Freq. BIT	–			X		–		–	
Low Freq. BIT	X			–		X		X	

– = Not Applicable
X = Applicable
* Operating & Non-Operating

Table 1-2 (continued)

ULTRA-BROADBAND ISOTROPIC PROBES

Probe Model	8741	8722
Type	E-Field (Flat)	E-Field (Shaped to ANSI Std.)
Freq. Ranges	.3 MHz to 40 GHz	
Power Ranges Full Scale (Equivalent Power Density)	.2 2 mW/cm^2 20	3 30% of Std. 300
Field Strength Full Scale (Mean Squared Field Strength)	8,000 80,000 V^2/m^2 800,000	Frequency Dependent
Calibration Accuracy	+/-.5 dB	
Isotropic Response	+/-1.5 dB	+/-.75 dB
Ellipse Ratio	+/-.75 dB	
Freq. Sensitivity .3 MHz to 40 GHz	+3/-1.5 dB	+/-2 dB from ANSI Std.
3 MHz to 40 GHz	+/-1.5 dB	–
CW Overload	200 mW/cm^2	10 dB above Full Scale
Peak Overload	15 W/cm^2	
Calibration Frequencies MHz	.3, 3, 10, 30, 100, 300, 750, 1000	
Calibration Frequencies GHz	1.7, 2.45, 4, 8.2, 10, 18, 26, 40	
Temp. Sensitivity	1%/C° < 1500 MHz .15%/C° > 1500 MHz	
Zero Offset	1%/C° (typical)	
Linearity	1% above 1500 MHz, 2% below 1500 MHz	
High Freq. BIT	X	X
Low Freq. BIT	X	X

– = Not Applicable
X = Applicable

PREPARATION FOR USE AND INSTALLATION

2-1. INTRODUCTION. This section contains procedures for unpacking the test set, inspecting the test set for shipping damage and for preparing the test set for use. Also included are pre-operational tests and adjustments.

2-2. PREPARATION FOR USE. To prepare the test set for use, perform the procedures contained in the following subparagraphs:

a. Unpacking Procedures. Do not unpack the test set within an area where RF radiation is suspected. The carrying case includes an RF shield to protect the probe from exposure to RF levels in access of damage levels during transportation and storage.

b. Inspection. To inspect the test set prior to use, perform the procedures contained in the following subparagraphs:

(1) Remove the meter assembly and probe assembly from the carrying case.

(2) Visually inspect the carrying case, meter assembly and probe assembly for evidence of shipping damage.

(3) Report any damage in accordance with applicable regulations.

c. Pre-operational Tests. Prior to performing a pre-operational check, review the procedures contained in Section 4, Operating Instructions. To perform a pre-operational test, refer to Figure 2-1 (8716) or Figure 2-2 and paragraph 2-3 (8711) and perform the procedures contained in the following subparagraphs:

(1) Make certain function selector switch A1S1 (8) of the meter assembly is set to OFF.

(2) Connect connector P1 (7) of the probe assembly to PROBE connector J1 (6) on the meter assembly.

(3) Set NORMAL/MAX HOLD switch S1 (2) to NORMAL.

(4) Set function selector switch A1S1 (8) to BAT TEST 1, depress probe test switch S2 (3) and observe that meter M1 (1) indicates BATTERY OK. If indication of meter M1 does not indicate BATTERY OK, refer to and perform the battery charging procedures contained in paragraph 5-2.

(5) Set function selector switch A1S1 (8) to BAT TEST 2 and observe that the pointer of meter M1 (1) indicates BATTERY OK. If indication of meter M1 does not indicate BATTERY OK, refer to and perform

the battery charging procedures contained in paragraph 5-2.

NOTE

The following step should be performed in an area of zero RF field and/or place probe in carrying case and close but do not latch cover.

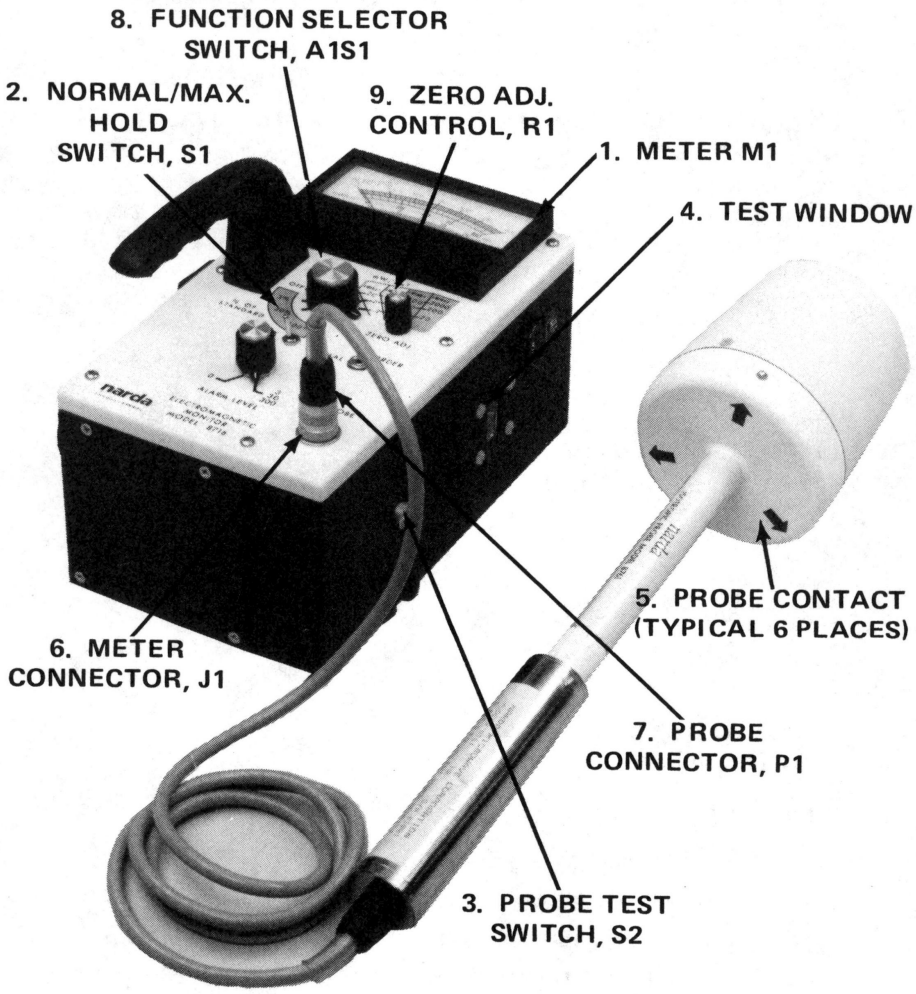

8. FUNCTION SELECTOR SWITCH, A1S1
2. NORMAL/MAX. HOLD SWITCH, S1
9. ZERO ADJ. CONTROL, R1
1. METER M1
4. TEST WINDOW
5. PROBE CONTACT (TYPICAL 6 PLACES)
6. METER CONNECTOR, J1
7. PROBE CONNECTOR, P1
3. PROBE TEST SWITCH, S2

Figure 2-1. Probe Orientation During Pre-Operational Testing (Model 8716)

(6) On meter assembly, set function selector switch A1S1 (8) to 3% range and observe that the pointer of meter M1 (1) is aligned with the ZERO mark of the meter scale. If necessary, adjust ZERO ADJ control (9) until pointer of meter M1 (1) is aligned with the ZERO mark.

(7) Set function selector switch A1S1 (8) to 30%.

(8) On a workbench or table or other flat surface, set meter assembly on its back. Alternatively, the meter assembly may be held in the left hand and the probe in the right hand. Hold probe tube near sensor end.

(9) Carefully align one of the probe contacts (5) with probe test switch S2 (3).

(10) Carefully apply pressure to probe test switch S2 (3) and move cap of probe until it contacts test window (4).

(11) Observe pointer of Meter M1 (1) for movement upscale. Failure of meter to move upscale indicates a malfunction of the test set. On some model probes the pointer movement during test may require 20 to 30 seconds to reach upscale position.

(12) Release pressure on probe test switch S2 (3) and observe that the pointer of meter M1 (1) is aligned with the ZERO mark of the meter scale.

(13) Repeat steps (9) through (12) for each of the five additional contacts (5) on the probe assembly. (Models 8722 or 8741 only.)

(14) Set function selector switch A1S1 (8) to OFF, or make survey in accordance with the procedures contained in paragraph 4-5.

2-3. Pre-Operational Tests (8711). Prior to performing a pre-operational check, review the procedures contained in Section 4, Operating Instructions. To perform a pre-operational test, refer to Figure 2-2.

(1) Make certain function selector switch S2 (2) of the meter assembly is set of OFF.

(2) Connect connector P1 (5) of the probe assembly to PROBE connector J1 (4) on the meter assembly.

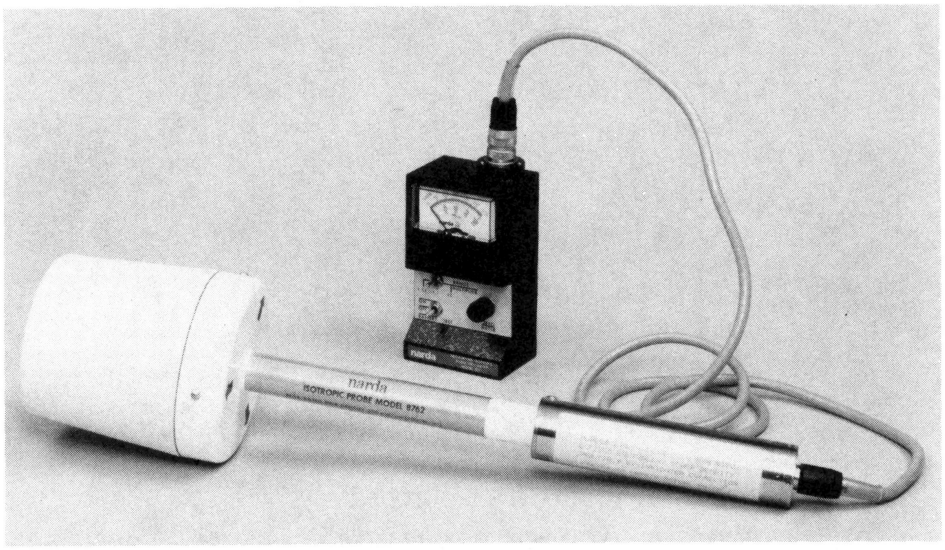


Figure 2-2. Model 8711 Pre-Operational Testing

(3) Set function selector switch S2 (2) to BAT TEST and observe that the pointer of meter M1 (1) indicates BATTERY OK. If indication of meter M1 does not indicate BATTERY OK, refer to and perform the battery replacement procedures contained in paragraph 5-2.

NOTE

The following step should be performed in an area of zero RF field and/or place probe in carrying case and close but do not latch cover.

(4) On meter assembly, set function selector switch A1S1 (2) to x 1 range and observe that the pointer of meter M1 (1) is aligned with zero mark of the meter scale. If necessary, adjust ZERO ADJ control (3) until pointer of meter M1 (1) is aligned with zero. Then set function selector switch A1S1 (2) to x .1 range and observe that the pointer of meter M1 (1) is still aligned with zero mark of meter scale. If not, adjust ZERO ADJ control until pointer is again aligned with zero. Set function selector to x .01 and repeat procedure for zeroing.

(5) Set function selector switch A1S1 (2) to OFF, or make survey in accordance with the procedures contained in paragraph 4-5.

SECTION III

GENERAL THEORY OF OPERATION

3-1. GENERAL. This section provides an overall functional description of the test set. Following the overall functional description of the test set, detailed functional descriptions of the probe and meter assemblies are provided.

3-2. OVERALL FUNCTIONAL DESCRIPTION. The test set is a portable, battery-operated instrument consisting of an interconnected probe assembly and a meter assembly. The test set is designed to detect potentially hazardous electromagnetic radiation and to display the radiation level on the meter front panel. The probe assembly detects the electromagnetic radiation, and transmits a signal to the meter assembly for display. The meter assembly processes the signals from the probe for display on a built-in meter. The meter displays the radiation level as percent of the Radio Frequency Protection Guides (RFPG) for Model 8722 and mW/cm^2 for other 8700 Series probes. The following subparagraphs contain a functional description of the probe and meter assemblies.

a. Probe Assembly Functional Description. See Figure 3-1. The probe assembly senses the electromagnetic radiation and develops a signal for transmission to the meter assembly. The probe assembly has an isotropic sensing pattern so that the radiation may be sensed from any

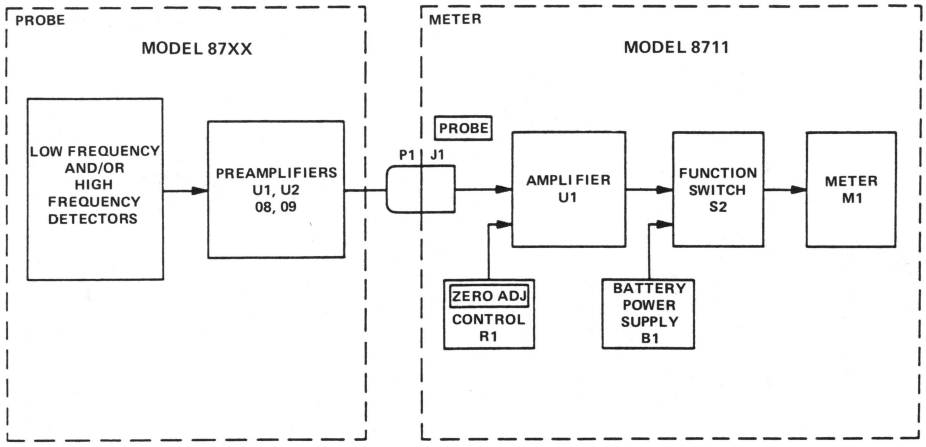


Figure 3-1. Radio Frequency Radiation Test Set
Functional Block Diagram (1 of 2)

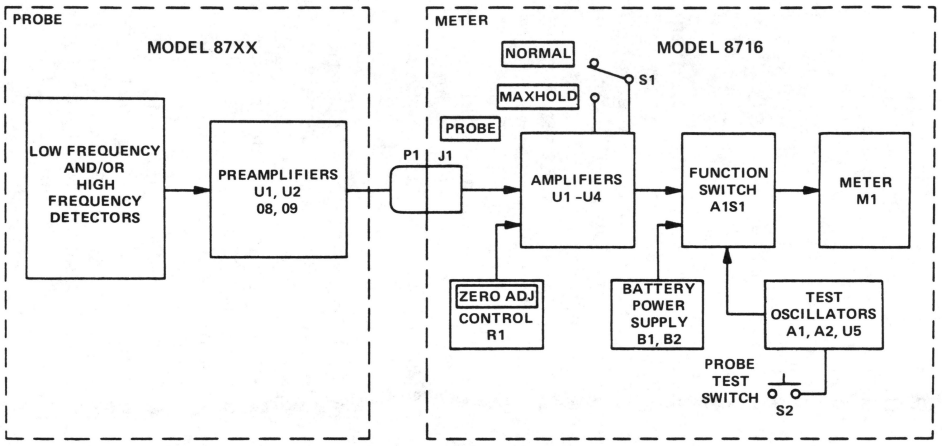


Figure 3-1. Radio Frequency Radiation Test Set
Functional Block Diagram (2 of 2)

direction, except through the handle. Detectors in the probe assembly sense the electromagnetic radiation present and apply signals to preamplifiers U1 and U2 located within the probe assembly. Preamplifiers U1 and U2 amplify the signals from the detectors and route them to the meter assembly via connector P1.

b. Meter Model 8711 Assembly Functional Description. The meter assembly receives the signals from the probe, processes the signals and provides a visual display of the maximum allowable exposure percentage. Signals received from the probe assembly at PROBE connector J1, are routed to amplifier U1. Amplifier U1 amplifies the signals from the probe assembly and generates a signal to drive the meter M1. The output of amplifiers is routed to Meter M1 via function switch A1S1.

c. Meter Model 8716 Assembly Functional Description. The meter assembly receives the signals from the probe, processes the signals and provides a visual display of the maximum allowable exposure percentage. Signals received from the probe assembly at PROBE connector J1, are routed to amplifiers U1-U4, U8 and U9. Amplifiers U1-U4, U8 and U9 amplify the signals from the probe assembly and generate a signal to drive the meter M1. The output of amplifiers is routed to Meter M1 via function switch A1S1. The operation of amplifiers is controlled by NORMAL/MAX HOLD switch S1. When the switch is set to the NORMAL position, meter M1 will display the

instantaneous radiation level sensed by the probe assembly. When NORMAL/MAX HOLD switch S2 is set to MAX HOLD, meter M1 will display the highest radiation level sensed by the probe assembly. The display of the highest radiation level is reset when the NORMAL/MAX HOLD switch S1 is set to NORMAL or when the test set is turned off.

The meter assembly also contains built-in self testing facilities for checking the condition of the batteries, the operation of the probe assembly and for zero adjustment of the probe assembly. The operation of the test set for these functions is described in the following subparagraphs:

(1) Battery testing. The test set provides a means of testing the condition of batteries B1 and B2. When function switch A1S1 is set to BAT TEST 1 or BAT TEST 2, the respective battery is connected to meter M1. If the condition of the battery is satisfactory, the pointer of meter M1 will reach beyond the "test min" mark. If a battery is weak or dead, then meter M1 will not reach the "test min" mark, thereby informing the operator that the battery should be charged. The probe test switch can be depressed during the BAT TEST 1 test to insure battery capacity to operate built in test oscillator.

(2) Probe zero adjustment. The test set provides a means for checking and zero adjusting the meter and probe assemblies. When function switch is in an operate mode and the probe is in zero field, the pointer of meter M1 is normally aligned with the ZERO mark. If not, ZERO ADJ control R1 is used to adjust the operation of amplifiers U1-U4 so that the pointer of meter M1 is aligned with the ZERO mark on the meter scale.

(3) Probe test. The test set provides a means of testing whether the probe is operational.

HIGH FREQUENCY - 12 GHz (nominal) oscillator and aperture for illuminating the probe. Power output is capable of producing a meter indication of approximately 10% of ANSI C95-1982 RFPG with Model 8722 probe or .75 mW/cm^2 with other E-field 8700 Series probes.

LOW FREQUENCY - External test point provides a 10 kHz (nominal) signal at the unit and test points on the probe to excite each of 3 low frequency elements and produce a meter indication of approximately 10% of ANSI C95.1-1982 RFPG with Model 8722 probe or .75 mW/cm^2 with other E-field probes.

When function switch A1S1 is set to the 30% range and the tip of the probe is aligned with the test window of the meter assembly, one of the perimeter contacts of the probe is used to operate test switch S2. When test switch S2 is operated, oscillators A1, U5 within the meter assembly generate test signals that are sensed by the probe assembly, causing the pointer of meter M1 to move to approximately midscale. If no pointer motion is observed, either the probe or the meter assembly may be defective.

3-3. PROBE GENERAL DESCRIPTION. The .3 MHz to 40 GHz electromagnetic radiation probe Model 8722 provides a frequency sensitivity characteristic that is the inverse of the C95.1 1982 ANSI Standard Radio Frequency Protection Guide, thus providing for metering in percent of RFPG. The shaping and broadband range is accomplished using three modes of detection.

3-4. LOW FREQUENCY ELEMENT. In the lower frequency region below 1500 MHz, where the sensitivity varies by 20 dB, a dipole with diode detector and both distributed and discrete components is used.

Three sensors are supported at one end of the probe along mutually orthogonal axes, each sensor consisting of a dipole-diode combination. Each diode is shunted with circuitry to modify the frequency response to

the induced signals so that the DC voltage output of the probe is proportional to the exposure level.

The resistive transmission line carries the modified signals to the metering circuits. These metering circuits include a pre-amplifier to condition the signals prior to transmission over the flexible cable for display on the metering instrument. The pre-amplifier contains the controls for calibration.

The conditioning amplifier lowers the impedance of the signals, preventing cable modulation by the flexible cable and also provides full time automatic zero control. The pre-amplifier is a true differential amplifier contributing good common rejection thereby reducing the susceptability to static charges. To further enhance this characteristic, a high resistance film covers the probe surface. The resistance is sufficiently high as to appear transparent to the radio frequency signal while providing a discharge path for static charges.

A lumped equivalent circuit of a dipole-diode sensor is shown in Figure 3-2. The segments illustrated separately as Ca1, Ca2, La1, La2, represents the dipole equivalent capacitance and inductance. When considering the combined effect of such reactances, they will be referred to as Ca and La. Similarly, the voltage induced in the dipole by the illuminating energy is represented by separate sources e. The equivalant resistance of the dipole is Ra. Note that the dipole is constr-ucted of conductive and resistive segments.

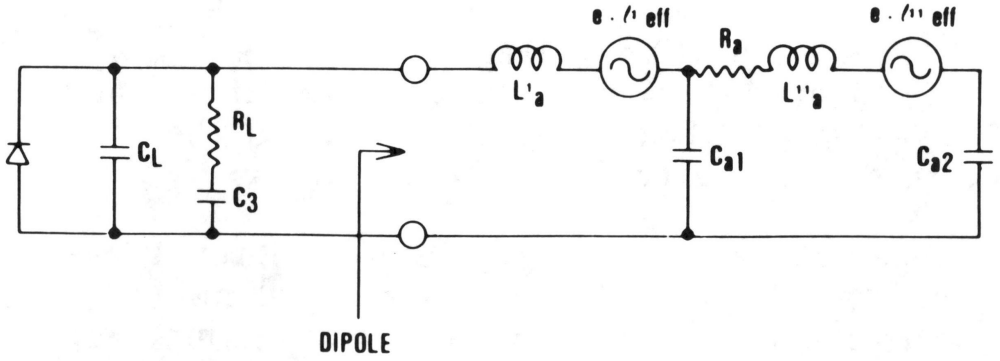


Figure 3-2. Lumped Equivalent Circuit of Dipole-Diode Sensors

In the frequency range of 30 to 300 MHz, the equivalent circuit simplifies to that of Figure 3-3.

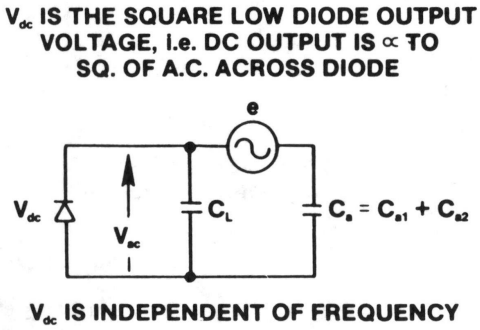

Vdc IS THE SQUARE LOW DIODE OUTPUT VOLTAGE, I.e. DC OUTPUT IS ∝ TO SQ. OF A.C. ACROSS DIODE
e
Vdc
Vac
CL
Ca = Ca1 + Ca2
Vdc IS INDEPENDENT OF FREQUENCY

Figure 3-3. Equivalent Circuit for 30 to 300 MHz

The dipole resistance Ra and dipole inductance reactance of La are negligible compared to the dipole capacitive reactance Ca. Within this range C2 is selected to have a very low reactance and the resistance of R2 is selected to be extremely high relative to the reactance of shunting capacitor C1. The dipole capacitance Ca and the shunting capacitance C1

act as a capacitive voltage divider having a uniform output with frequency over this range. The value of C1 is selected to obtain the desired sensitivity from the diode.

Descending in frequency and commencing at 30 MHz, the shape of the response is principally controlled by the resistance RL in conjunction with the reactance of shunting capacitor CL and dipole capacitance Ca.

The equivalent circuit then reduces to the one shown in Figure 3-4.

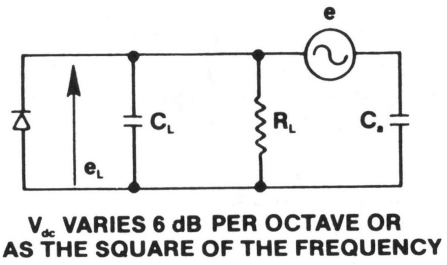


Figure 3-4. Equivalent Circuit for 3 to 30 MHz

The radio frequency voltage across the diode varies at a 6 dB per octave rate as the frequency decreases to 3 MHz. The diode having a square-law characteristic, provides a DC output voltage proportional to the square of the radio frequency voltage across the diode. The diode output sensitivity therefore decreases as the square of frequency ($1/f^2$).

Descending still further in frequency, at approximately 3 MHz the reactance C2 increases to the magnitude where it exceeds the resistance RL and the equivalent circuit reduces to approximate the schematic of Figure 3-5.

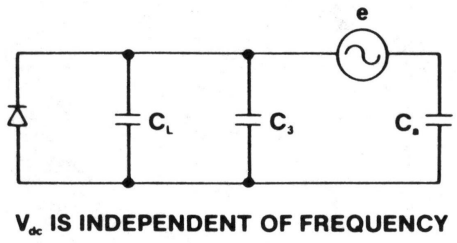


Figure 3-5. Equivalent Circuit for Frequencies below 3 MHz

Hence, the circuit again performs as a capacitive divider having a constant sensitivity for frequencies below 3 MHz.

Within the frequency range above 300 MHz and 1.5 GHz, the dipole characteristics are selectively modified to achieve controlled roll-off. The dipole is constructed of conductive and resistive portions, as illustrated in Figure 3-6.

The conductive portion connects to a resistive film portion of the terminals of the diode. The extent and location of the resistive film portion of the dipole is selected to achieve the desired character-

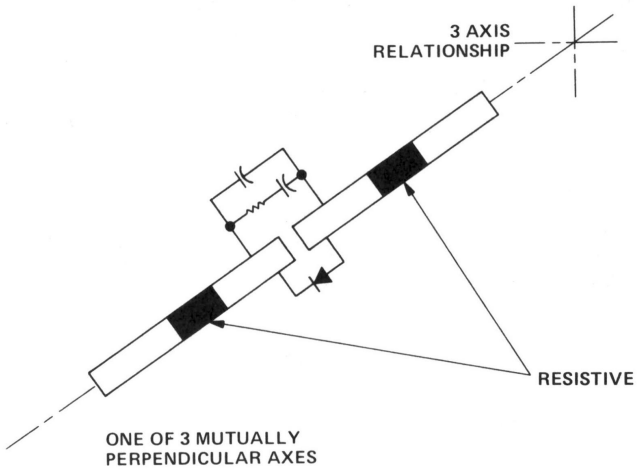


Figure 3-6. Pictorial View of Dipole Showing Resistive and Conductive Segments

istics. When the frequency increases above 300 MHz, the resistance of this film predominates over the reactance of that portion of the antenna. If the entire dipole had been constructed of resistance material, the sensitivity would decrease at a 6 dB per octave rate, or $1/f^2$. To approximate the desired 1/f (3 dB per octave) rate, only a portion of the dipole is made resistive. The resistivity in the present case is chosen to start roll-off at 300 MHz. That portion of the conductive dipole contributes a signal to the diode that is constant over the frequency range thereby achieving the desired reduction in sensitivity to approximate 1/f. The diode operates in its

square-law region and the induced voltages are made approximately equal for both conductive and resistive portions.

In the low to high frequency transition (300 MHz to 1.5 GHz range), the equivalent circuit of Figure 3-4 reduces to that of Figure 3-7, where the resistance RL is much greater than the shunting reactance of C1 and the dipole reactance La is negligible.

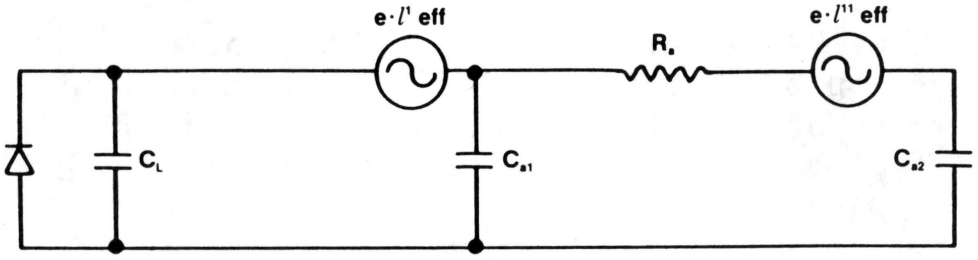


Figure 3-7. Equivalent Circuit for 300 MHz to 1.5 GHz

Under these circumstances the diode output voltage Vd becomes:

$$Vd = k\left[eLeff + \frac{eLeff}{f}\right]^2$$

The response of the diode sensor thus decreases as the frequency increases.

The resistivity of the dipole and the concomitant decreasing sensitivity, prevents affecting the response in the high frequency region as the dipole approaches resonance. The values of capacitance and inductance for the sections of the dipole can be calculated from the average characteristic impedance for each portion of the dipole. The equation for characteristic impedance Z_o is:

$$Z_o = \frac{1}{H_2 - H_1} \int_{H_1}^{H_2} 120 \ln \frac{(2r)}{a} \, dr$$

where H1 and H2 define the limits of each portion of the dipole, and a is the effective radius of the dipole. The equation can then be integrated over the portion of the antenna in question.

Using the expression for La and Ca

$$La = Z_o(8fo)^{-1}$$

$$Ca = (2fo Z_o)^{-1}$$

The frequency response of a typical unit is illustrated in Figure 3-8. (A $\pm$ 2 dB margin that conforms to the ANSI Standard is also drawn on the graph).

Calibration factors are provided at multiple points over all frequency intervals making more precise measurements possible when the source frequency is known.

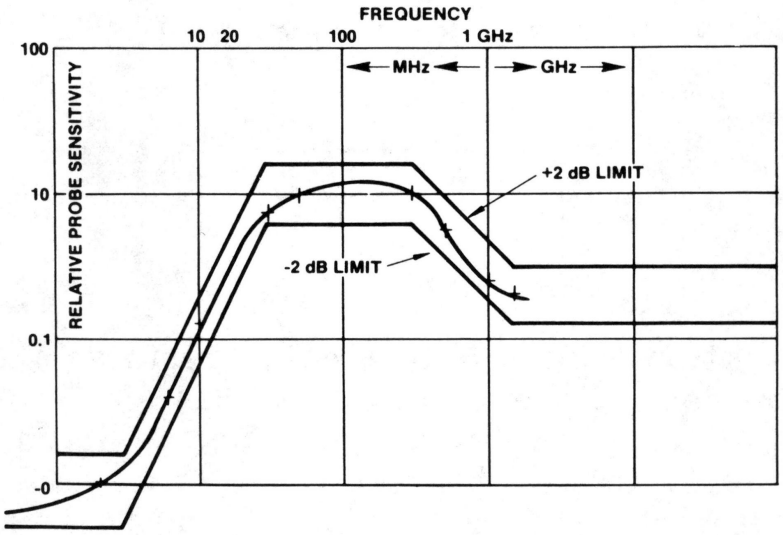


Figure 3-8. Frequency Response of Probe with ±2 dB Margins Conforming to C95.1-1982 Standard

As previously stated, the three dipoles are mutually orthogonal and the diodes are operated in their square law region. This region is defined as that in which the dc diode current is proportional to the square of the electric field tangential to the dipole L = K times E squared.

For a free space plane wave power flow S1 may be expressed in terms of E and the intrinsic impedance of free space.

$$S_1 = \frac{E^2}{\eta_o}$$

Power density S is equal to the sum of the squares of the coordinate field strengths divided by the space impedance = 377

$$S = \frac{E_X^2 + E_y^2 + E^2}{\eta_o}$$

$$S = K[i_X + i_y + I_Z]$$

Deviation from the preceding results in a polarization ellipse ratio as well as an isotropic response deviation. The maximum observed of this probe is $\pm$.75 dB. Very little perturbation of the field occurs. Over the major portion of its range, the dipole is a small fraction of a wavelength and thereby couples very lightly into the field. The resistive portion of the dipole, in addition to providing the desired roll-off characteristic, also limits the coupling into the field. No resonance of the probe is observed. Response of the low frequency elements above 1.5 GHz is a smooth monotonic curve with sensitivity decreasing as the frequency increases. This response is shown in Figure 3-9.

The components used in the construction are beam lead diodes and chip capacitors and resistors. In addition, the diode is piggy-backed on its shunting capacitor C2. C2 and the diode form a loop which can couple into the magnetic field at high frequencies where the reactance is sufficiently low to permit induced currents to flow. These design selections minimize this possible coupling into the magnetic field.

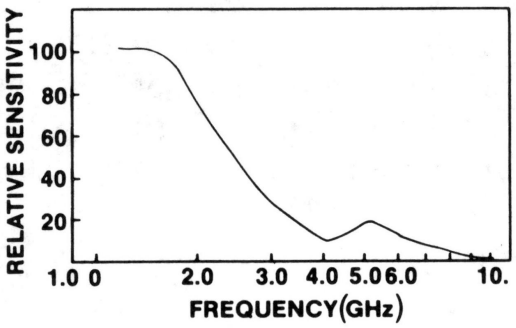


Figure 3-9. Low Frequency Element Response

Another subtle problem with which the design deals is the possible diode response to light energy. The unencapsulated beam diode can (and does) in classic manner have a response to light. This phenomena will cause down scale readings. The sun illuminating the junction of a beam lead diode will inject minority carriers. This reduces the barrier level and produces a voltage across the junction equal to the reduction. This photo voltaic effect is completely eliminated by a black film coating surrounding the sensor assembly.

3-5. HIGH FREQUENCY ELEMENT. The element which is used in the higher frequency region functions in two modes. Between 1500 MHz and approximately 18 GHz, it is a resistive dipole. Above 12 GHz it utilizes the phase relay of a traveling wave to produce additional output. As a resistive dipole, in the 1.5 to 18 GHz region, each probe contains three mutually perpendicular elements.

Resistive thermocouples are distributed along the length of the dipole at spacings that will not permit resonance over the operating range of frequencies (see Figure 3-10). The dipole may be viewed as a group or series connected small resistive dipoles or as a very low Q resonant circuit.

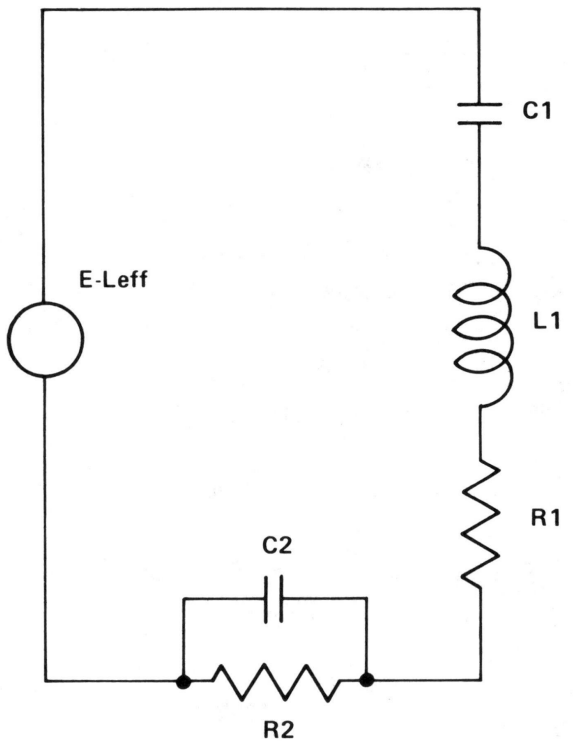


Figure 3-10. Lumped Equivalent Circuit of the Probe with Single Elements Relative to the Total Probe. R2 Represents One of the Distributed Thermocouples

A lumped equivalent schematic representation of a probe element is shown in Figure 3-10. R2 and C2 represent a terminal load of one of the probe elements (center-fed dipoles) and L1, C1 are the lumped equivalent inductance and capacitance of the probe element determined from the average characteristic impedance Z_o.

The dipole when oriented tangential to the electric field will have an induced current proportional to the electric field in the region where the distributed resistance of the dipole is greater than the reactance of the dipole. This current will heat the dissimiliar resistive deposited films producing a thermoelectric output voltage proportional to the square of the electric field. As the reactance of the dipole increases above the dipole resistance, the induced current is proportionately reduced, in lowered sensitivity. This occurs above 12 GHz and below 1.5 GHz.

Above 12 GHz as the element sensitivity decreases another mode of operation becomes manifest. In this mode, the dipole is aligned along the Poynting Vector with the cold junctions oriented tangential to the electric field. Each of the three mutually orthogonal elements contains four resistive dipoles with the cold junctions oriented at right angles. This provides for the independence of probe orientation relative to the polarization of the field.

The instantaneous charge distribution on adjacent cold junction elements produce a potential difference across the thin film resistive thermocouples and a resultant dissipation of energy in these films. As the frequency increases, the phase difference between the potentials developed in adjacent also increases the open circuit voltage.

$$V_{oc} = \int_{o}^{H} \frac{E\,Sin\beta(H-h)}{Sin\beta H} \left[e^{JWT} - e^{Jiwt-Br}\right] dh$$

$$\frac{V_{oc}}{E} = \frac{\lambda(1-Cos\beta r)}{\pi - Sin\beta H} (1-Cos\beta H)$$

An equivalent circuit (see Figure 3-11) can be developed from a transmission line analysis of a pair of adjacent elements. The resistive thermocouple terminates two open circuited transmission lines:

The characteristic impedance of the line,

$$R_o = 276 \log D/r$$

and the open circuit impedance of the transmission line,

$$Z_{oc} = -jRCot. \frac{2\pi S}{\lambda}$$

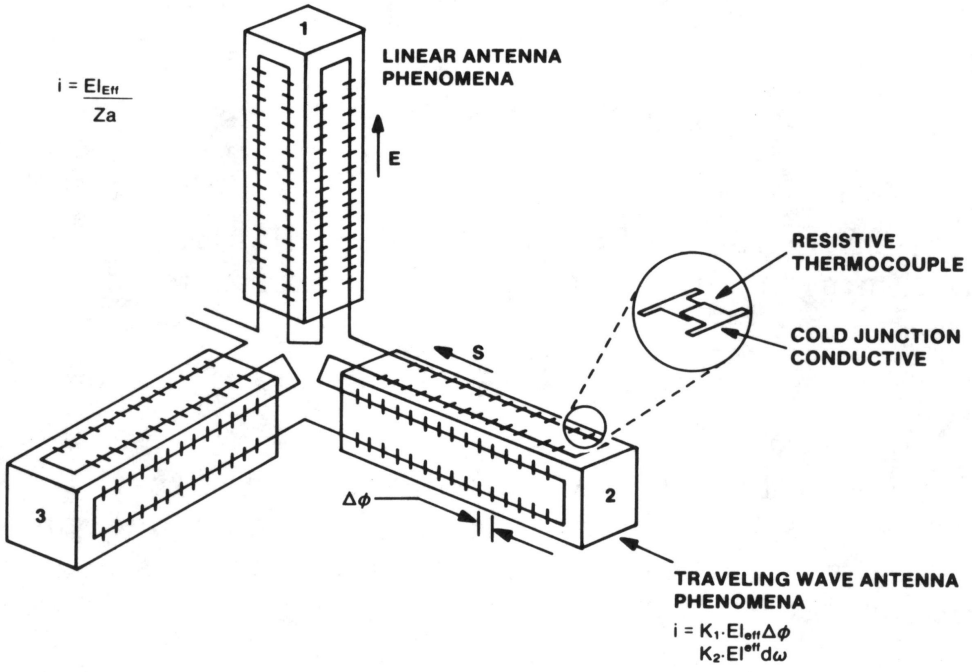


Figure 3-11. High Frequency Elements

The reactance across the thermocouple is the parallel connection of both transmission lines. Therefore,

$$Xc = Zoc$$

$$Xc = Zoc/2$$

$$Ca = \frac{\lambda}{\left[2\pi c138 \log \frac{d-r}{r}\right] \operatorname{Cot} \frac{2\pi s}{\lambda}}$$

The transmission line inductance contributes

$$La = 4 \times 10^{-7} \left(\log \frac{d-r}{r}\right) (2s)$$

The radiation resistance of both dipoles, assuming a sinusoidal current distribution is:

$$Ra = \frac{160\pi^2 s^2}{\lambda^2}$$

In the table below VT2 is proportional to the power dissipated in the thin film thermocouple and the resultant dc thermoelectric voltage generated.

CALCULATED RESPONSE OF TRAVELING WAVE MODE

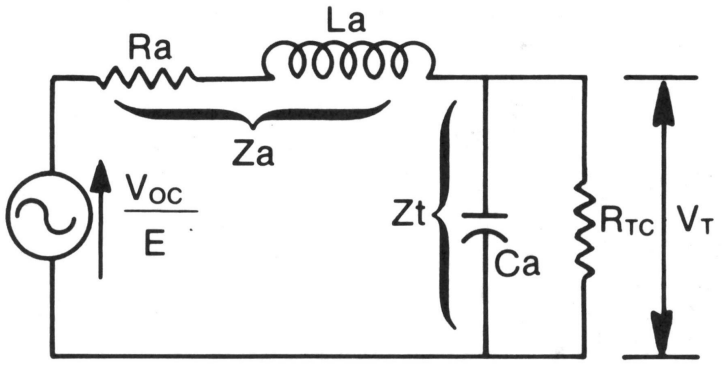
FREQUENCY GHz	$\frac{V_{OC}}{E}$	$(V_T)^2$
12	25.5×10^{-6}	3×10^{-9}
18	58.2×10^{-6}	12×10^{-9}
40	284×10^{-6}	10.4×10^{-9}

The combined response from the low frequency dipole-diode element and two modes of operation of the resistive dipole is shown for the frequency range in Figure 3-12, together with the recommended maximum ANSI C95.1-1982 exposure levels.

3-6. PROBE AMPLIFIER. Dual probe amplifiers located in the handle are connected to the probe elements by inflexible monolithic resistive leads. This prevents cable modulation from affecting the signal derived from the elements.

These amplifiers are commutating auto zero instrumentation amplifiers to provide automatic zeroing of the meter. Each instrumentation amplifier consists of three distinct sections, two analog, one digital. The two analog sections, a differential to single ended voltage converter and a commutating auto zero amplifier have on-chip analog switches to steer the input and output signals. While one op amp is processing the signal the second op amp is in auto zero mode, charging a capacitor to a voltage equal to its DC error voltage. The amplifiers are connected and reconnected at a 5 kHz rate, so that all times one or the other of the on-chip amplifiers is processing the signal while the error voltages are being updated to compensate for variables such as low frequency noise voltage and input, offset voltage changes due to temperature, drift or supply voltage effects.

The reference voltage for zero is provided by the output of the bridge consisting of R1-R2 and thermistors Th1 and Th2. This bridge provides a correction voltage for the pyroelectric voltage generated by the amplifier input feedthru capacitors. The rate of adjustment is accomplished by the setting of potentiometer R7. The absolute zero reference is established by R101 in the meter.



$$Ca = \frac{\lambda}{\left[2\pi c\ 138 \log \frac{d-r}{r}\right] \text{Cot } 2\ \frac{\pi s}{\lambda}}$$

$$La = 4 \times 10^{-7} \left(\log \frac{d-r}{r}\right) (2s)$$

$$Ra = \frac{160\pi^2 s^2}{\lambda^2}$$

From Transmission Line Theory

Figure 3-12. Traveling Wave Mode Equivalent Circuit

3-7. PROBE SELF TEST PROVISIONS.

a. Test Points. Each probe has either 3 high frequency or 3 low frequency test points, with the exception of Models 8722 and 8741 which have both high and low frequency test points. When the probe test switch (Figure 2-1, (3)) is depressed (Model 8716 only) both high and low frequency test sources are enabled, causing a clearly visable upscale

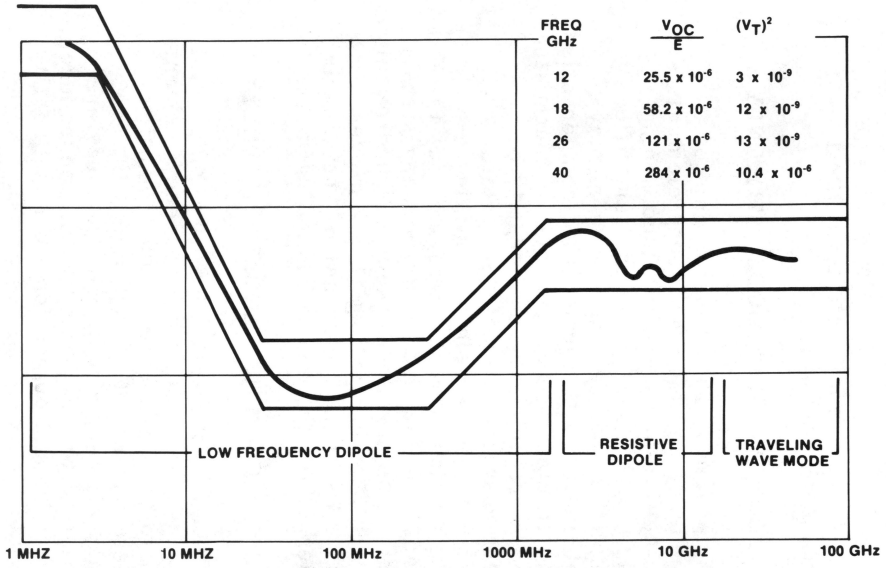


Figure 3-13. Combined Frequency Sensitivity and ±2 dB of ANSI C95.1-1982 RFPG

indication on the meter to confirm satisfactory operation of that element. Table 2-1 lists which probes are applicable to either low or high frequency testing.

3-8. METER CIRCUITS (MODEL 8711 ONLY).

Input Amplifiers. The probe outputs of the low frequency and high frequency elements are fed to their respective input conditioning amplifiers of a Quad operational amplifier. One amplifier provides the low frequency element circuit with temperature compensation thru the temperature dependance of thermistor TH1 and correction for non-linearity by nonlinear characteristic of CR1. Both amplifiers provide a gain of 2 driving a summing amplifier, and the segment of the Quad, which adds the low and high frequency signals together. Ranging is also accomplished in this latter amplifier controlling the gain over three 10 dB steps. The output of the summing amplifier drives the analog indicating meter.

3-9. METER CIRCUITS (MODLE 8716 ONLY).

a. Input Amplifiers. The probe outputs of the low frequency and high frequency elements are fed to their respective input conditioning amplifiers U4 and U1. U1 provides the low frequency element circuit with temperature compensation thru the temperature dependence of thermistor T1 and correction for non-linearity by non-linear characteristics of CR2. Both U1 and U4 provide a gain of two and a full scale voltage of 2 at TP1 and TP2. U2 is a summing amplifier which adds the low frequency and high

frequency signals together. U3 is the ranging amplifier and controls the gain over three 10 dB steps. The output also provides a recorder output of volts full scale at a minimum load resistance of 1000 ohms.

b. Indicator Circuits. The indicator circuits consist of amplifiers U8, U9 and the meter. There are two modes of operation, Max Hold and Normal. In the Normal mode, Switch S1 shorts out CR6, and U8, U9 operate as linear cascaded amplifiers with unity gain. In this mode the meter becomes a portion of the summing resistor of the feedback network consisting of R27 and R28.

In the Max-Hold mode of operation, switch S1 is open allowing CR6 to become functional within the circuit. The amplifiers now operate as a peak holding circuit in which the charge stored on C9 is proportional to the maximum power density surveyed. U8 has a MOSFET input which together with the extremely high back resistance of CR6 prevents leakage of the charge in C9. When S1, the Normal/Max Hold mode switch is momentarily set to normal, capacitor C9 discharges and resets the circuit.

Potentiometer R28 calibrates the meter at full scale.

3-10. ALARM SECTION (MODEL 8716 ONLY). Comparitor U10, and transistor Q1 provide the threshold circuitry and driver for audible alarm G. The threshold value is set from front panel potentiometer R102. Panel calibration

for this potentiometer is from 0 to 100% at full scale indication and resistor R13 provides for the adjustment of the calibration.

When the signal level from the output of U2 exceeds the threshold level, transition from a negative to positive voltage occurs at the output of U10. This drives Q1 into conduction, excites G and sounds the audible alarm. The alarm ceases when the signal level drops below the threshold and a polarity reversal again occurs at the output of U10. The operation of this circuit is independent of the Max-Hold/ Normal switch.

3-11. POWER SUPPLY (MODEL 8711 ONLY). A single common 9 volt transistor battery NEDA Type 1604 powers the meter. A load current of 1.5 milliamperes, permit approximately 150 hours of use time at a 2 hour/day rate. Battery condition can be measured using the BATTERY TEST switch position to display battery voltage relative to a minimum acceptable level.

3-12. POWER SUPPLY (MODEL 8716 ONLY). The primary power source for the Model 8716 is two 9 volt NiCad batteries. Two, three-terminal voltage regulators, U6 and U7, provide ± 5 volt stabilized supplies to reduce zero offset due to battery use and the resultant reduction in battery voltage. U6 provides the negative supply voltage and U7 provides the positive supply voltage. The two NEDA 1602 batteries will provide a minimal of 30 hours use with a 2:1 use to charge ratio.

3-13. SELF TEST SOURCES (MODEL 8716 ONLY). Low frequency test source is provided by U5 which produces a 10 kHz test signal to be injected thru low frequency test points on probe. High frequency test source is provided by A1 which produces a 12 GHz signal at its aperture. This oscillator uses a FET for maximum power efficiency. Both low frequency and high frequency sources are energized simultaneously when the test button is pressed. The test button itself is the low frequency test point.

SECTION IV

OPERATING INSTRUCTIONS

4-1. GENERAL. This section contains instructions for evaluating radiation sources using the test set and provides safety precautions when working in a potentially hazardous radiation area. Also included is detailed information relating to the controls and indicators of the test set as well as start up, normal, abnormal and shut-down procedures for the test set.

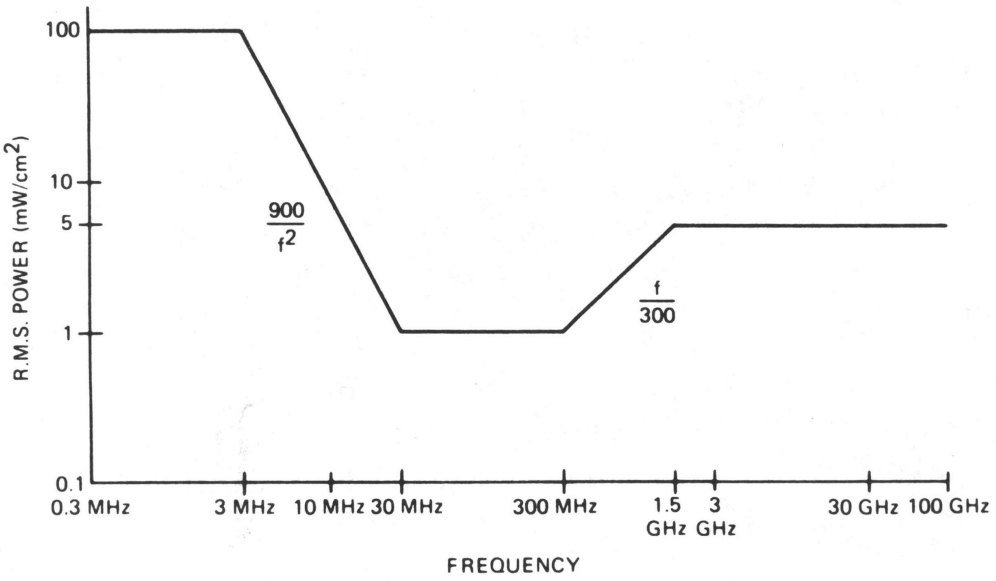
4-2. PERCENTAGE OF RADIO FREQUENCY PROTECTION GUIDES EVALUATION. The PERCENT OF RFPG scale of meter M1 is used to display the potential personnel hazard from a radiating source (see Figure 4-2 for Model 8716 and Figure 4-3 for Model 8711). Use the guideline contained in the following paragraphs for interpreting the meter readings.

4-3. SAFETY PRECAUTIONS. The following contain information pertaining to personnel safety while working in a hazardous radiation environment.

The ANSI Radio Frequency Protection Guide (C95.1-1982) (RFPG) covers the recommended levels for the 300 kHz to 100 GHz range. A summary of the standard is included on the next page for informational purposes.

Frequency Range (MHz)	Power Density* (mW/cm2)	E2* (V2/m2)	H2* A2/m2
0.3-3	100	400,000	2.5
3-30	900/f2	4,000 (900/f2)	0.025 (900/f2)
30-300	1.0	4,000	0.025
300-1500	f/300	4,000 (f/300)	0.025 (f/300)
1500-100,000	5	20,000	0.125

Notes: f is the frequency, in MHz
*Whole body exposure averaged over any 0.1-hour (6-minute) period.



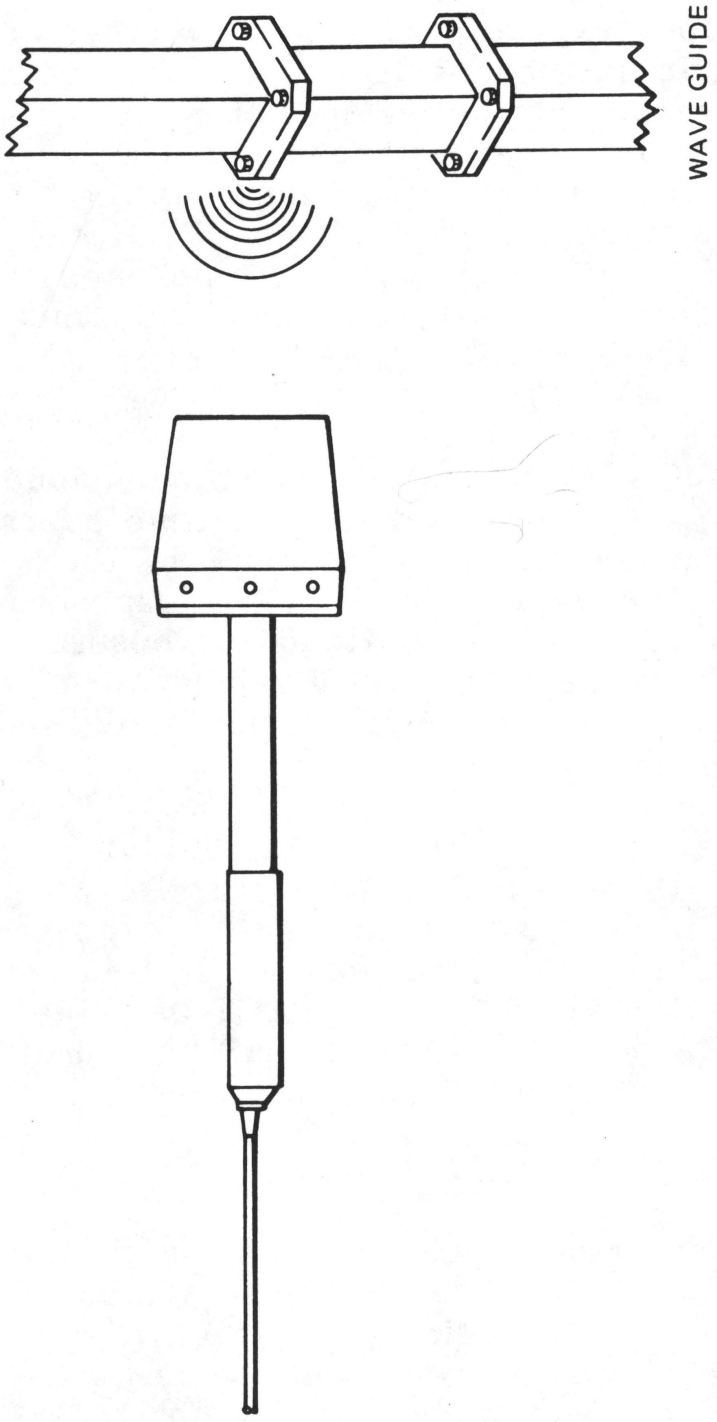


Figure 4-1. Probe Orientation During Use

Whole body exposure averaged over 0.1 hour. Both electric and magnetic fields must be measured separately below 300 MHz (near field exposure). For mixed or broadband fields consisting of a number of frequencies for which there are different values of the RFPG, the fraction of the RFPG incurred within each frequency interval shall be determined, and the sum of all such fractions shall not exceed unity.

Below 100% of C95.1-1982 RFPG, continuous exposure is permissible, since the time averaged value will always be less than 100% of the standard. However, INTERMITTENT exposure to levels in excess of the continuous exposure level whose average over an 0.1-hour (6-minute) period is less than or equal to the RFPG is also permissible.

Example: exposure to 2.0 mw/cm^2 at frequency of 100 MHz (200% of std) for 3 minutes, followed by 3 minutes of 0 exposure, 3 minutes of 2.0 mW/cm^2 exposure, 3 minutes of 0 exposure, etc. (a 50% DUTY FACTOR) yields a TIME AVERAGED VALUE of 1.0 mW/cm^2 or 100% of std.

WARNING

Do not enter a suspected radiation field until a safe level has been ascertained. If location or direction of propagation of source is not known, hold probe at 45 degrees to the ground, deck or horizontal surface with arm outstretched (See Figure 4-1). If the source location is known,

point the probe towards it with the arm outstretched. Always approach an area of a suspected radiation or radiating equipment carefully. When a meter reading is observed, do not approach the unit under test or radiating source any closer than necessary to verify the source and levels of radiated signals. Move probe within the area to find the exact site of the radiating source. If measurements are greater than the limits of the C95.1-1982 RFPG, back away from the area until a safe level is observed, or the exposure time is limited so that the average over a six-minute period does not exceed 100%.

4-4. OPERATING CONTROLS AND INDICATORS. Figures 4-2 and 4-3 show the operating controls and indicators for the test sets. Table 4-1 lists and describes each control and indicator of the Model 8716 meter test set and Table 4-2 describes each control and indicator for the Model 8711 meter.

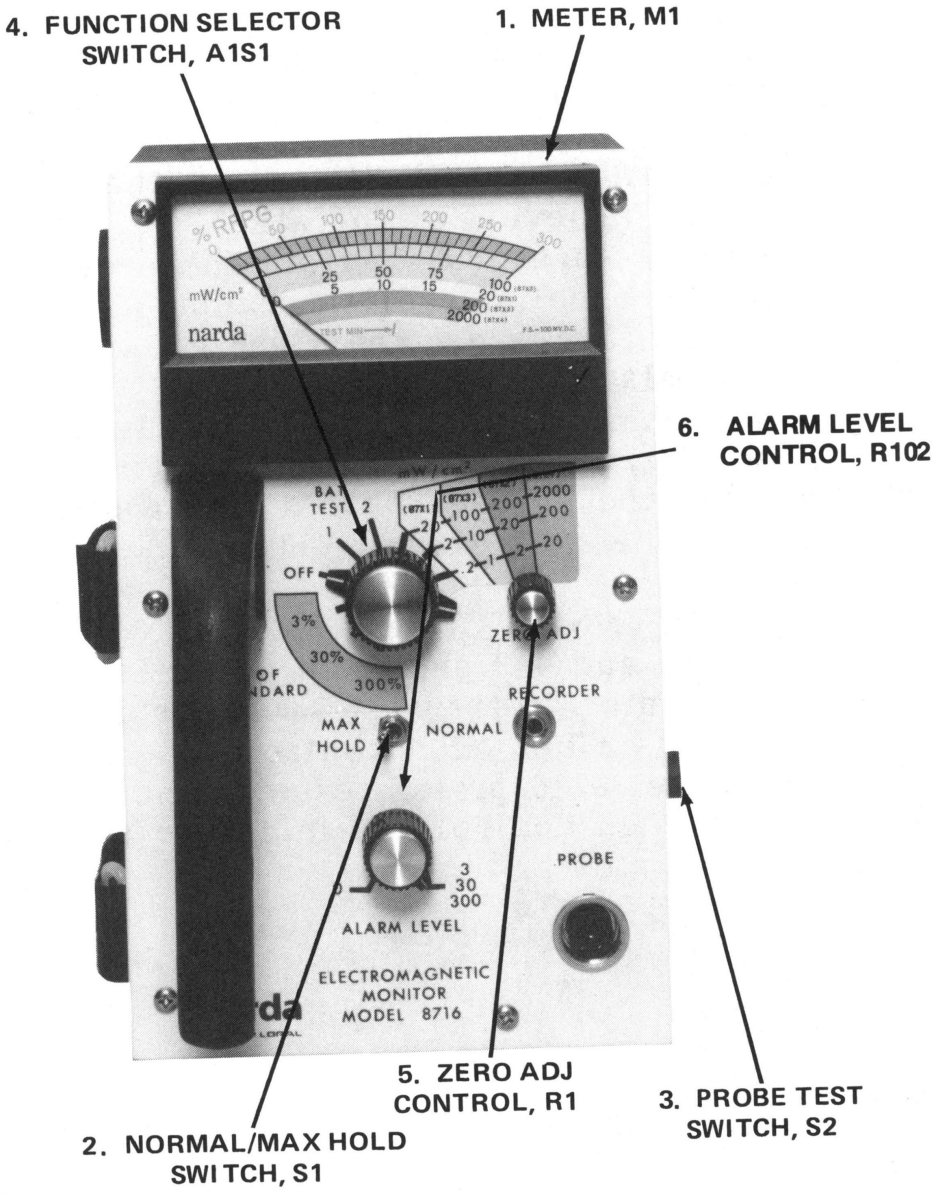


Figure 4-2. Model 8716 Controls and Indicators

Table 4-1

Test Set Controls and Indicators

Figure and Index No.	Control or Indicator	Function
4-2-1	Meter M1	Indicates percentage of the allowable exposure level. The top portion of the scale indicates percent of exposure level measured from 0.3% to 300%. The bottom portion of the scale is marked in mW/cm2 for use with other 8700 series probes. TEST MIN Marker. Indicates the condition of the batteries. A reading upscale of the TEST MIN mark indicates the batteries are satisfactory for use.

Table 4-1 (Cont)

Figure and Index No.	Control or Indicator	Function
4-2-2	NORMAL/ MAX HOLD Switch S1	Selects operating mode of meter assembly during measurements as follows: NORMAL Position. Displays the instantaneous RF Radiation level on meter M1. MAX HOLD Position. Displays and holds the maximum RF Radiation reading on Meter M1. Meter M1 reading is reset when NORMAL/ MAX HOLD Switch is set to NORMAL or Function Selector switch A1S1 is set to OFF.
4-2-3	Probe Test Switch S2	Energizes internal signal source for testing probe.

Table 4-1 (Cont)

Figure and Index No.	Control or Indicator	Function
4-2-4	Function Selector Switch, A1S1	Selects the test set function and meter M1 scale to be used for measurements, as follows: OFF. Turns off test set. BAT TEST 1. Indicates the condition of battery No. 1 on the scale of meter M1. BAT TEST 2. Indicates the condition of battery No. 2 on the scale of meter M1. Lowerscale Display mW/cm^2, full scale values are dependent upon probe. Upper Scale (8722) 300% Range. Displays % of RFPG on meter with full scale value of 300%.

Table 4-1 (Cont)

Figure and Index No.	Control or Indicator	Function
4-2-4 (Cont)		30%. As above except full scale value is 30%. 3%. As above except full scale value is 3%.
4-2-5	ZERO ADJ Control, R1	Used to adjust meter M1 for ZERO SET indication.
4-2-6	ALARM LEVEL Control R102	Used to adjust alarm level, based on meter M1 deflection.

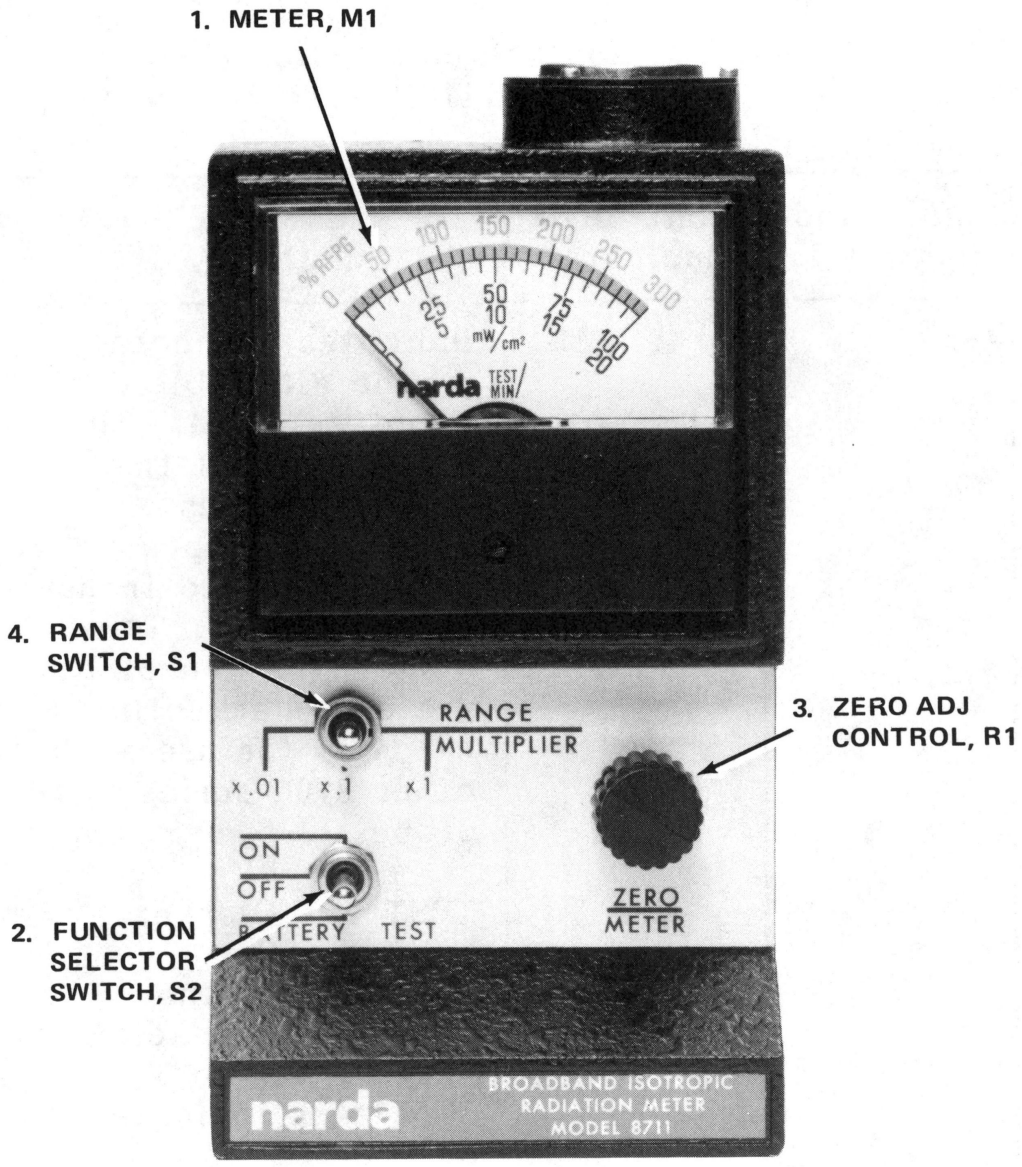


Figure 4-3. Model 8711 Controls and Indicators

Table 4-2

Test Set Controls and Indicators
For Model 8711 Meter

Figure and Index No.	Control or Indicator	Function
4-3-1	Meter M1	Indicates percentage of the allowable exposure level. The top portion of the scale indicates percent of exposure level measured from 0.3% to 300%. The bottom portion of the scale is marked in mW/cm^2 for use with other 8700 series probes. TEST MIN Marker. Indicates the condition of the battery. A reading upscale of the TEST MIN mark indicates the battery is satisfactory for use.

Table 4-2 (Cont)

Figure and Index No.	Control or Indicator	Function
4-3-2	Function Selector Switch, S2	Selects the test set function and meter M1 scale to be used for measurements, as follows: OFF. Turns off test set. BAT TEST. Indicates the condition of battery on the scale of meter M1. ON. Energizes test set.
4-3-3	ZERO ADJ Control, R1	Used to adjust meter M1 for ZERO SET indication.
4-3-4	Range switch S1	Selects range multiplier.

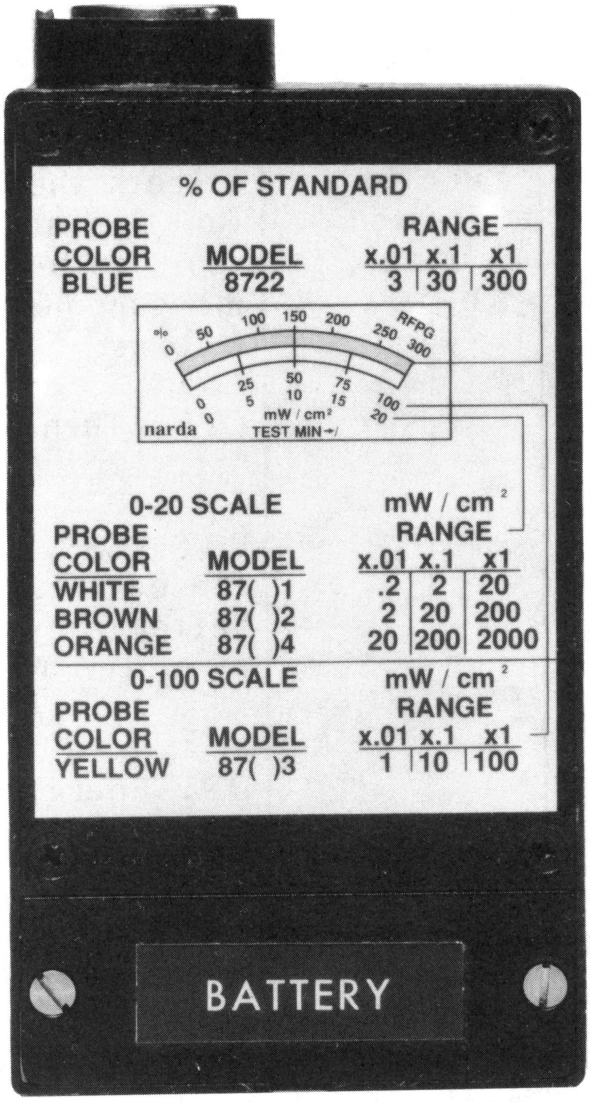


Figure 4-4. Model 8711 Rear View

4-5. OPERATING PROCEDURES (MODEL 8716). The following steps should be followed for the Model 8716. Refer to 4-6 for the Model 8711. To start up, operate, operate under abnormal conditions and shut-down the test set, perform the procedures contained in the following subparagraphs:

CAUTION

Do not place the test set, operating or non-operating in an area where fields are expected to exceed a 300% reading as damage to the test set may result.

a. Initial Start-Up Procedures. To start-up the test set, refer to Figure 2-1 and perform the procedures contained in the following subparagraphs.

(1) Make certain Function Selector Switch A1S1 (8) of the meter assembly is set to OFF.

(2) Connect connector P1 (7) of the probe assembly to PROBE connector J1 (6) on the meter assembly.

(3) Set NORMAL/MAX HOLD switch S1 (2) to NORMAL.

(4) Set Function Selector Switch A1S1 (8) to BAT TEST 1 and observe that Meter M1 (1) reads above the TEST MIN mark. If indication of Meter M1 does not display above TEST MIN mark, refer to and perform the battery charging or replacement procedure contained in paragraph 5-2 for the Model 8716.

(5) Set Function Selector Switch A1S1 (8) to BAT TEST 2 and repeat Step 4.

NOTE

The following step should be performed in an area of zero RF field and/or place probe in carrying case and close but do not latch cover. Alternately, the probe elements may be shielded by wrapping them with a piece of Aluminum foil.

(6) On meter assembly, set Function Selector Switch A1S1 (8) to most sensitive scale, observe that the pointer of Meter M1 (1) is aligned with the ZERO mark of the meter scale. If necessary, adjust ZERO ADJ control (9) until pointer of Meter M1 (1) is aligned with the ZERO mark.

(7) Set Function Selector Switch A1S1 (8) to 30%. The pointer of Meter M1 (1) should stay on zero mark.

(8) On a workbench or table or other flat surface, set meter assembly on its back. Alternatively, the meter assembly may be held in the left hand and the probe in the right hand.

(9) Carefully align one of the probe contacts (5) with Probe Test Switch S2 (3).

(10) Carefully apply pressure to Probe Test Switch S2 (3) and move cap of probe until it contacts test window (4).

(11) Observe pointer of Meter M1 (1) for movement upscale. Failure of meter to move upscale indicates a malfunction of the test set. On some model probes the pointer movement during test may require 20 to 30 seconds to reach upscale position.

(12) Release pressure on Probe Test Switch S2 (3) and observe that the pointer of Meter M1 (1) is aligned with the ZERO mark of the meter scale.

(13) Repeat steps (9) through (12) for each of the five additional contacts (5) on the probe assembly.

(14) Make survey in accordance with para. 4-5(b).

b. Normal Operating Procedure. To operate the test set, refer to Figure 4-1 for the Model 8716 and Figure 4-2 for the Model 8711 and perform the procedures contained in the following subparagraphs.

NOTE

The meter assembly may be hand held utilizing the front panel handle or carried using the shoulder strap. The probe assembly may be hand held or secured to the side of the meter assembly. (Model 8716 only.)

(1) If probe assembly is to be secured to the meter assembly, position handle of probe as shown in detail A of Figure 2-1. Secure probe assembly by passing fastener strap (1) around handle of probe assembly, through D ring (11) and folding fastener strap back on itself. (Model 8716 only.)

(2) Set Function Selector Switch to most sensitive range.

(3) Set NORMAL/MAX HOLD switch (2) to NORMAL if a continuous indication of the RF radiation present is required or to MAX HOLD if a sustained indication of the maximum RF Radiation encountered is required. (Model 8716 only.)

WARNING

Always approach an area of suspected radiation or potentially hazardous equipment carefully. When a meter reading is observed, do not approach the unit under test or radiating source any closer than necessary to verify the

source of radiated signal and to measure the level of RF radiation present. Move probe within the area to find the exact site of the radiating source. If readings exceed the full scale reading on the most sensitive range, reset the test set to the middle range. If readings then are greater than the measuring range of the middle range of the probe in use, reset the test set to the maximum measuring range. When measuring microwave frequencies, move the test set probe slowly when searching for the highest RF level, to insure the maximum measuring level capability of the probe is not exceeded.

CAUTION

Do not place the test set, operating or non-operating in an area where fields are expected to exceed full rated power density as damage to the test set may result.

NOTE

If a full-scale reading is observed on Meter M1 (with range switch in 300% or maximum mW/cm2 position), leave the area immediately and refer to paragraph 4-5.a. and repeat the initial start-up procedures to verify that the probe or meter assembly has not been damaged.

(4) Approach the area or equipment cautiously, starting as far away as possible and keep the probe extended at arms length toward the radiation source. Hold the probe to point towards radiating source.

(5) Observe meter (1, Figure 4-2) for indication of RF Radiation.

(6) Slowly move the probe in a horizontal and vertical arc while observing meter (1) to determine the direction of maximum signal.

(7) Hold probe stationary and allow indication on Meter M1 to stabilize.

(8) For each measurement, observe and record the indication on the PERCENT OF RFPG scale of meter (1) if using Model 8722 or mW/cm^2 when using other 8700 series probes.

NOTE

In the case of a single radiating source, if the frequency is known, multiply the meter reading by the calibration factor listed on the handle of the probe assembly.

c. Adverse or Abnormal Operating Procedures. This paragraph contains procedures for operating the test set when moving the test set between

temperature extremes. Procedures are also provided for operating the test set in fields at frequencies below 1 MHz.

(1) Operation at temperature extremes. To operate the test set when moving between temperature extremes, allow the test set to stabilize at the new temperature condition for at least 20 minutes before use. If immediate operation is required, perform the procedure contained in the following paragraphs:

(a) Set function selector switch (4) to most sensitive range.

(b) Adjust ZERO ADJ control (5) until the pointer of Meter M1 (1) is aligned with the ZERO mark on Meter M1 (1).

(c) Set Function Selector Switch (4) to desired range and make required measurements.

(d) Repeat steps (a) through (c) at approximately five-minute intervals until no further adjustment of ZERO ADJ control (5) is required.

(2) Additional Uncertainties for Electric fields Below 1 MHz. When making electric field measurements below 1 MHz, uncertainties in the order of 3 dB are possible unless certain

precautions are taken. This uncertainty results from capacitively coupling into a high potential source. To avoid this effect, the probe should not be brought closer than 3 feet to an excited radiator in this frequency range. In addition, the probe and meter should be at the same approximate potential.

This can be accomplished by strapping the probe to the meter with the velcro fastener provided on the meter. The probe cable should be coiled and maintained close to the meter. Hold the meter by its insulated handle.

4-6. MODEL 8711 OPERATING PROCEDURES. To start up, operate, operate under abnormal conditions and shut-down the test set, perform the procedures contained in the following subparagraphs:

CAUTION

Do not place the test set, operating or non-operating in an area where fields are expected to exceed the probe full scale rating as damage to the test set may result.

a. Initial Start-Up Procedures. To start-up the test set, refer to Figure 2-2 and perform the procedures contained in the following subparagraphs.

(1) Make certain Function Selector Switch A1S1 (2) of the meter assembly is set to OFF.

(2) Connect connector P1 (5) of the probe assembly to PROBE connector J1 (4) on the meter assembly.

(3) Set Function Selector Switch A1S1 (2) to BAT TEST and observe that Meter M1 (1) reads above the TEST MIN mark. If indication of Meter M1 does not display above TEST MIN mark, refer to and perform the battery replacement procedures contained in paragraph 5-3.

NOTE

The following step should be performed in an area of zero RF field and/or place probe in carrying case and close but do not latch cover. Alternately, the probe elements may be shielded by wrapping them with a piece of Aluminum-foil.

(4) On meter assembly, set Range Switch A1S2 (6) to most sensitive scale, observe that the pointer of Meter M1 (1) is aligned with the ZERO mark of the meter scale. If necessary, adjust ZERO ADJ control (3) until pointer of Meter M1 (1) is aligned with the ZERO mark.

(5) Set Range Switch A1S2 (6) to x1. The pointer of Meter M1 (1) should stay on zero mark.

(6) Make survey in accordance with paragraph 4-5b. and c.

SECTION V

MAINTENANCE INSTRUCTIONS

5-1. GENERAL. This section contains maintenance instructions for the test set. These instructions include procedures for cleaning, battery charging or replacement. If the test set requires maintenance that is beyond the scope of this section, refer to Section VI, or return the set to Narda.

5-2. MAINTENANCE PROCEDURES. The following procedures contain maintenance instructions for cleaning the test set, replacing or recharging the batteries. Subparagraph a. contains procedures for cleaning the test set. Subparagraphs b. and c. contain procedures for battery charging (b) or replacement (c). Refer to paragraph 5-3 for Model 8711 battery replacement.

a. Cleaning. Mild solutions of household cleaners such as ammonia or dishwashing detergent can be used to loosen ground-in-dirt and grease from the exterior of the meter and probe assemblies. To clean the meter and probe assemblies, perform the procedures contained in the following paragraphs.

CAUTION

To prevent damage to the test set, do not allow moisture to collect on or within the test set. Use only damp cleaning cloths during cleaning operations.

1. Clean outer surface of the meter assembly and probe assembly with a clean cloth dampened with a mild dishwashing detergent or water solution.

2. Wipe dry using a clean, dry cloth.

3. Clean meter display window and test window using a mild ammonia and water solution.

4. Wipe dry using a clean, dry cloth.

b. Battery charging. See Figure 5-1. To charge batteries, perform the procedure contained in the following subparagraphs:

CAUTION

To prevent damage to meter assembly (1), make certain Function Selection Switch A1S1 is set to OFF. Insure the flag above the line cord connector on the Model 8716 indicates the proper charging voltage. The Model 8716 may be charged using either 115 or 230 VAC. To change the charging voltage or replace the NiCad batteries, refer to subparagraph (c).

1. Plug system into line voltage and allow to charge overnight (16 hours).

2. Check battery charge level, if battery charge level remains close to TEST MIN marking on meter M1 perform steps (3) through (5).

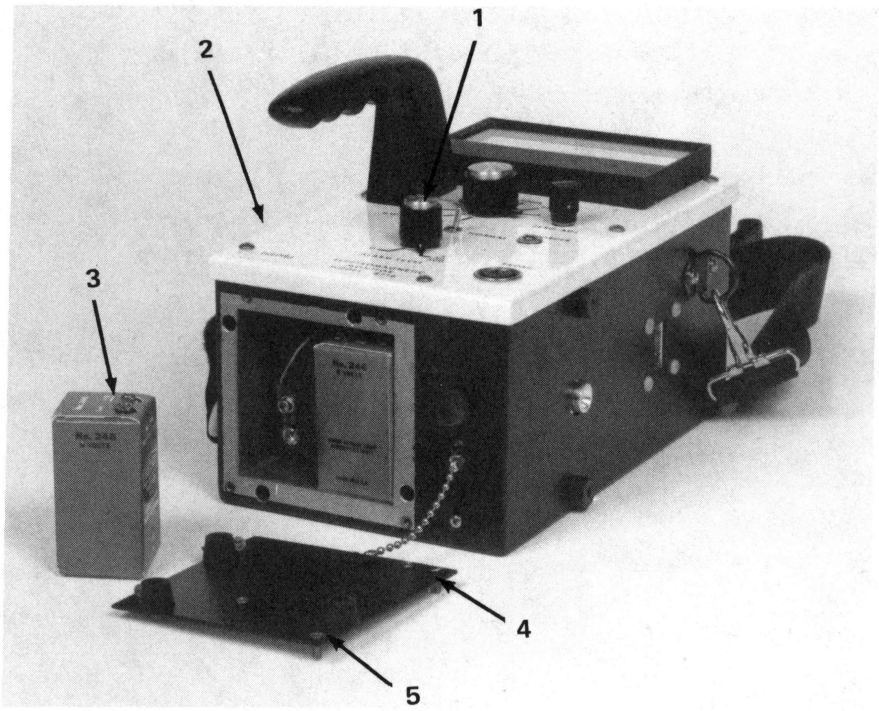


Figure 5-1. Radio Frequency Radiation Test Set, Battery Replacement (8716)

3. Place system in case (probe disconnected), turn function selector switch A1S1 to mid range. Allow system to discharge for 24 hours.

4. Charge system for 15 min. only. Then discharge system completely again.

5. Charge system overnight (16 hours). Insure battery charge level is above TEST MIN mark on meter M1. If batteries are not charged fully proceed with the instructions contained in subparagraph c.

c. Battery replacement. See Figure 5-1. To replace batteries, perform the procedure contained in the following subparagraphs:

1. Loosen screws (5) and remove cover (4).

2. Carefully remove battery (3) from battery compartment and disconnect battery connector (2).

3. Battery charge voltage should be verified or changed, to correspond with AC line voltage.

4. Connect replacement battery (3) to battery connector (2).

5. Carefully position battery (3) in battery compartment of meter assembly (1).

6. Position cover (4) over battery compartment and fasten with captive screws (5).

7. Check flag on rear cover. Insure flag voltage corresponds to switch selection (Step 3).

8. Set Function Selector Switch A1S1 to BAT TEST 1 and make certain that Meter M1 indicates above TEST MIN mark on Meter M1.

9. Set Function Selector Switch A1S1 to BAT TEST 2 and make certain that Meter M1 indicates above TEST MIN mark on Meter M1.

10. Set Function Selector Switch A1S1 to OFF. If batteries were replaced and are not fully charged, see page 5-1, Section 5-2 (b).

d. Battery Replacement Model 8711. See Figure 5-2. To replace batteries, perform the procedure contained in the following subparagraphs:

CAUTION

To prevent damage to meter assembly (1), make certain Function Selection Switch A1S1 is set to OFF.

1. Loosen two screws (5) and remove cover (4).

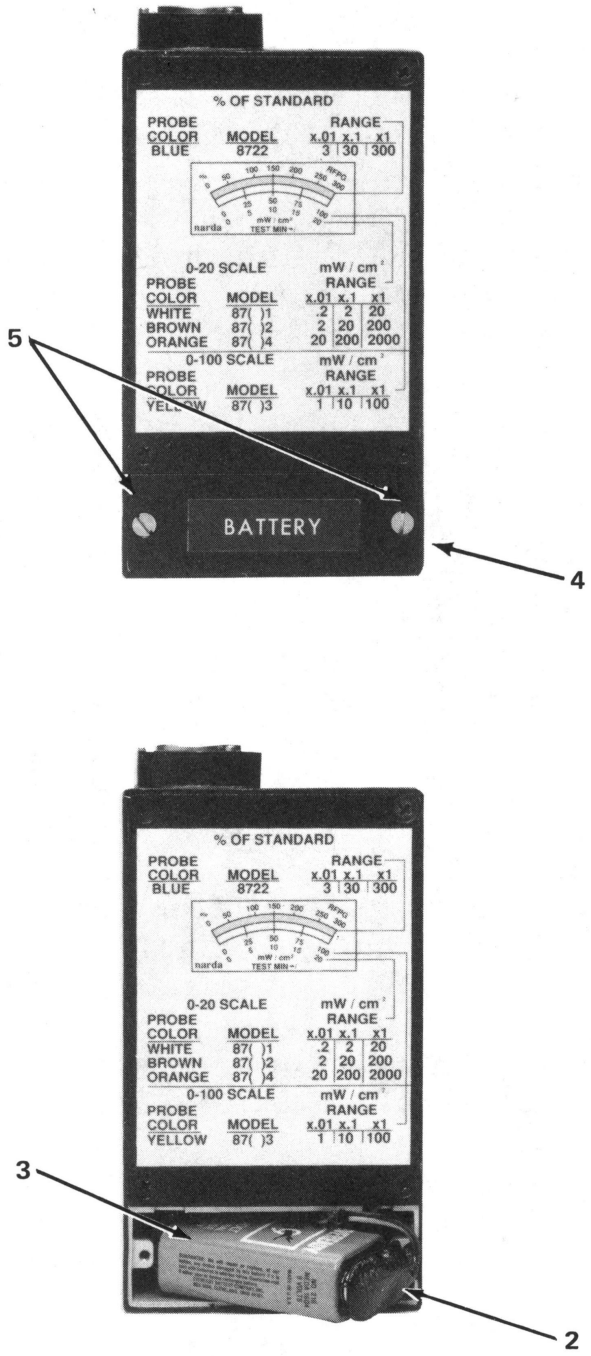


Figure 5-2. Radio Frequency Radiation Test Set, Battery Replacement (8711)

2. Carefully remove battery (3) from battery compartment and disconnect battery connector (2).

3. Connect replacement battery (3) to battery connector (2).

4. Carefully position battery (3) in battery compartment of meter assembly (1).

5. Position cover (4) over battery compartment and fasten with two captive screws (5).

6. Set Function Selector Switch S2 to BAT TEST and make certain that Meter M1 indicates above TEST MIN mark on Meter M1.

7. Set Function Selector Switch S2 to OFF.

SECTION VI

CALIBRATION & ALIGNMENT PROCEDURE

6-1. GENERAL. This section includes information on Calibration and Alignment procedures for the Model 8711 and 8716 meters and a general description of calibration procedures for the 8700 series probes. All probes are calibrated across their operating frequency range therefore, this section defines the various equipment needed to calibrate probes from 300 KHz to 40 GHz. The technician performing these calibrations should be aware of the particular probe to be calibrated and follow the cal. instructions for that particular frequency range. Calibrations should be performed annually for meters and probes.

6-2. TEST EQUIPMENT REQUIRED

a. Meters (8711 and 8716) only

(1) Oscilloscope Tek No. 2335

(2) Power Supply KEPCO ABC15-1M

(3) DC Dif. Voltmeter Fluke 895A

(4) Decade Attenuator GenRad 1450

(5) Resistor, 619 Ω +/- 1%, RN55 (2 ea.)

(6) Resistor, 330K +/- 5%, RC07

(7) Potentiometer, 10K

(8) Connector

6-3. Model 8711 CALIBRATION (REFER TO FIG. 6-11)

a. Connect Test Setup of figure 6-3. S-1 open. S-2 to high. Remove cal. decal on right side of meter.

b. Set 8711 to x1.0 range, energize meter and zero meter by adjusting R1, zero control.

c. Set decade attenuator to 10 dB. Close S-1, adjust power supply to +1.000 volts.

d. Adjust R19 for exact full scale reading (top potentiometer) on right side of meter.

e. Low frequency gain

(1) With decade attenuator set to 10 dB, insure voltmeter reads 1.000 volts.

(2) Set decade attenuator to 30 dB, set switch S-2 to low.

(3) Set 8711 to x1.0 range. Adjust R4 (bottom pot. right side) to maximum resistance.

(4) Adjust R3 (middle pot.) for exact full scale indication.

f. Linearity

(1) On test setup (Fig. 6-3) set S2 to low, S-1 open.

(2) With 8711 on x1.0 range, zero meter using R1, zero control.

(3) Set decade attenuator to 35 dB.

(4) Close S-1, adjust power supply for exact full scale reading.

(5) Set 8711 to x10 range (least sensitive). Reset attenuator to 17.2 dB.

(6) Adjust R4 (bottom pot.) for full scale reading.

g. Range Accuracy

(1) On test setup, set S-2 to high, S-1 open, Attenuator to 10 dB.

(2) On 8711, set range switch to x.1 range, and zero meter using R1, zero control.

(3) On 8711, set range switch to x10 range, close S-1, adjust power supply for full scale indication.

(4) Reset Attenuator to 30 dB, 8711 to x1 range, note full scale reading (atten. may be varied +/- .2 dB).

(5) Reset Attenuator to 50 dB, 8711 to x.1 range, note full scale reading (atten. may be varied +/- .2 dB).

(6) Calibration of Model 8711 is complete. Turn power off, disconnect test setup. Return system to storage case.

6-4. Model 8716 CALIBRATION

The adjustment procedure in paragraphs 6-5 through 6-10 are accomplished with the meter open to provide access to the adjustment potentiometers. The meter is opened by removing the six Phillips head screws from the periphery of the cover. (Figure 6-1) Before replacing the cover, be sure that the RF shielding finger stock is positioned on the 4 edges of the box.

6-5. INPUT AMPLIFIER GAIN (REFER TO FIG. 6-12)

a. Connect the test set up of Figure 6-3. (Note pin 7 is center pin, pin 6 is to the right of key, pin 1 is to the left of key) (see Figure 6-3).

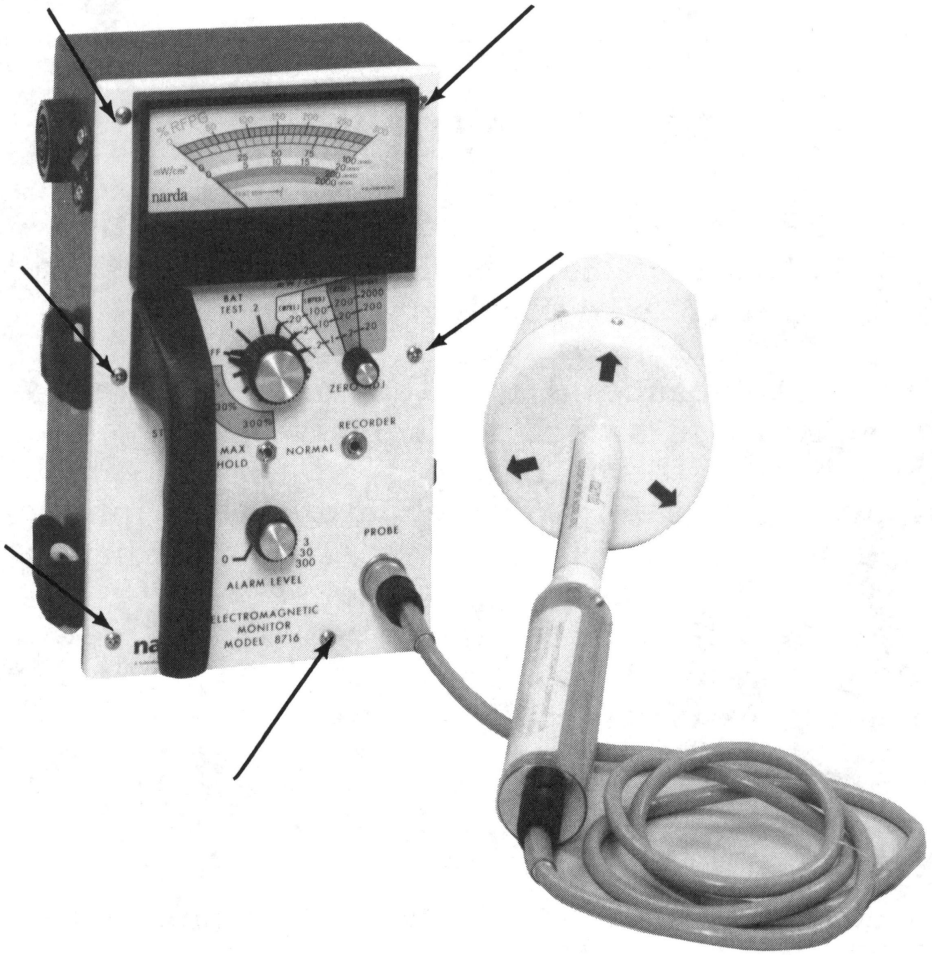


Figure 6-1. Front Panel Screw Locations

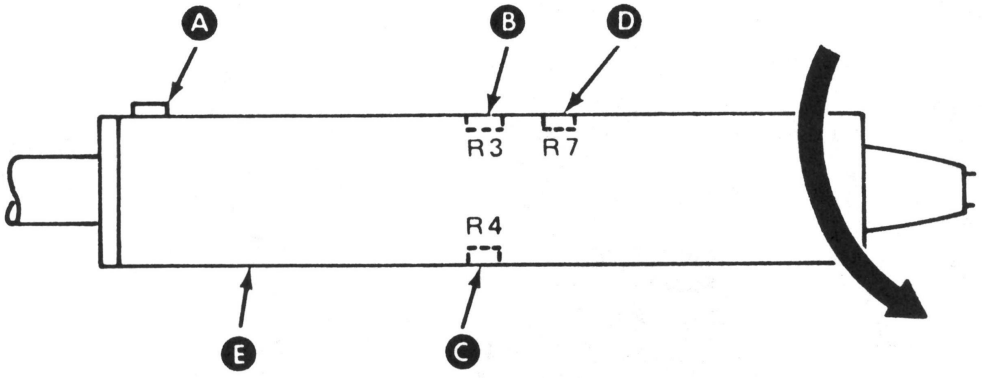


Figure 6-2. Pre-Amplifier Calibration Potentiometer Access. Remove Phillips Head Screw at Front of Handle (A)

b. Set decade attenuator to 10 dB. Set panel function switch to least sensitive scale. Set input switch of Figure 3, to low. Adjust supply voltage for an attenuator output voltage of -1.00 volts.

c. Set R18 for maximum resistance. Set attenuator to 30 dB. Set panel function switch to mid sensitivity scale.

d. Adjust R3 for a voltage at TP3 of -.200 volts. (Ref. E7 Ground)

e. Set input selector switch (Figure 6-3) to high.

f. Observe a voltage of -.200 volts at TP4. (Ref. E7 Ground)

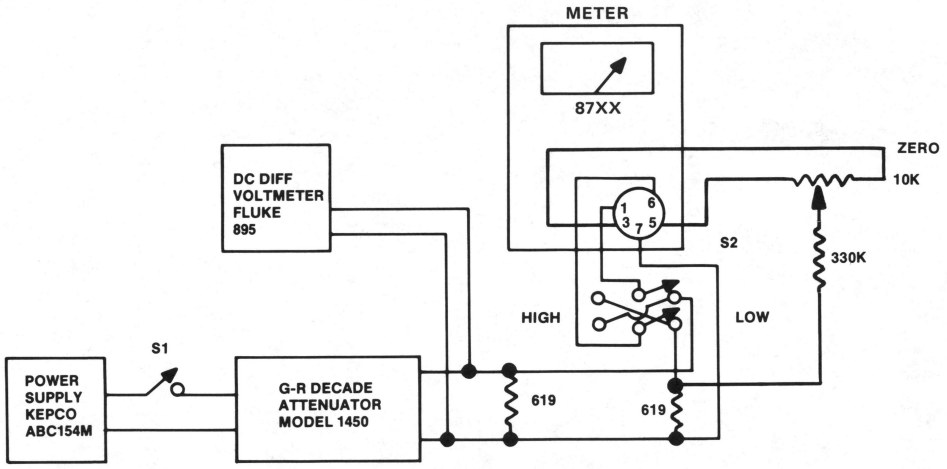


Figure 6-3. Meter Test Setup (Models 8711 and 8716)

g. Adjust R28 for exact full scale meter indication on 8716.

6-6. LOW FREQUENCY BITE OSCILLATOR

a. Connect oscilloscope probe to test button on right side of housing (see Figure 6-4). Depress button with oscilloscope probe and observe a 10 kHz ± 20% scope indication. Adjust peak to peak amplitude to 6.0 volts with R25.

6-7. MAX HOLD MODE

a. Set panel function switch to 300%. Set decade attenuator to 10 dB. Adjust power supply voltage for an exact full scale indication on the 8716 meter. Set Max hold, normal switch to max. hold.

b. Reset decade attenuator to 70 dB. Observe meter indication does not drop past the 290% mark in 11 minutes.

6-8. LINEARITY

a. Connect set up of Figure 6-3. Set S2 to low, S1 open.

b. Set 8716 to mid range, adjust zero.

c. Set decade attenuator to 35 dB, 30 +5 +0 dB.

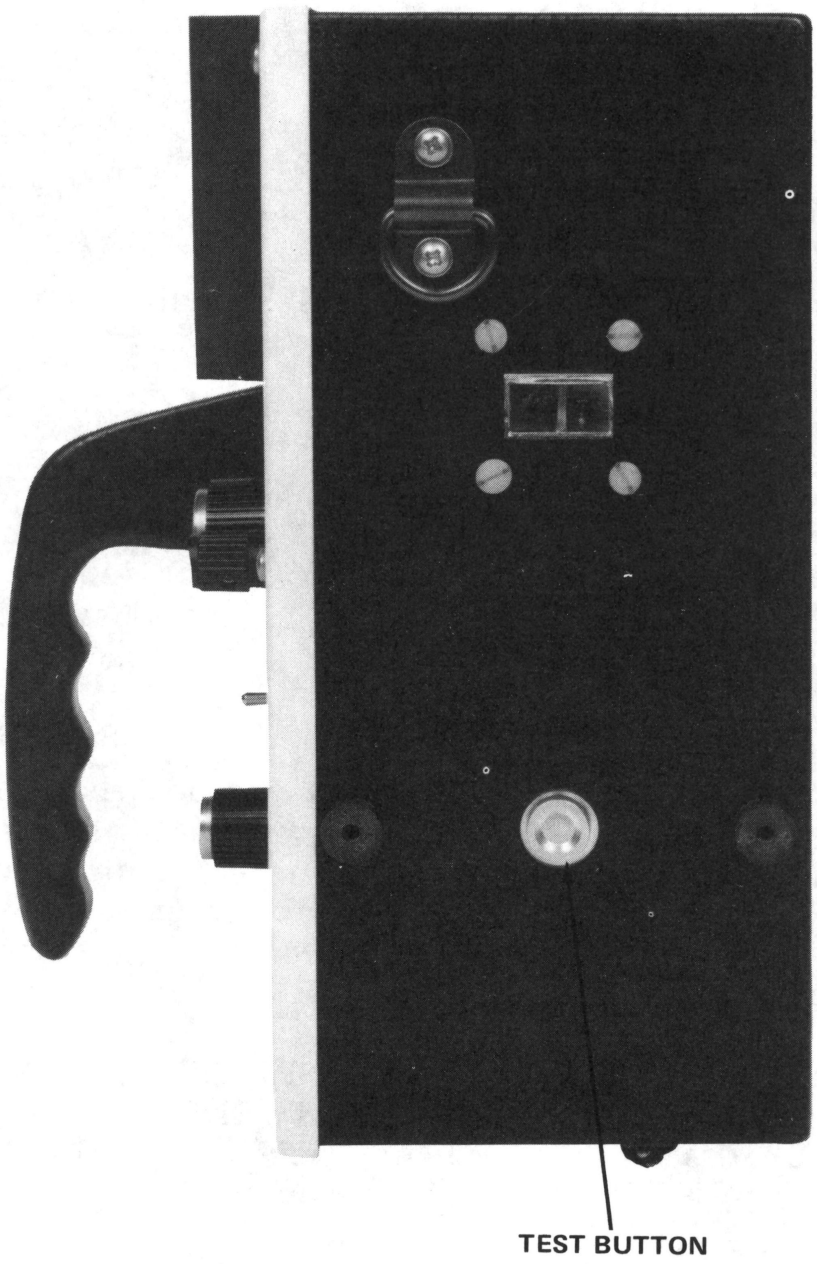


Figure 6-4. Bite Test Locations

d. Close S1, adjust power supply for exact full scale indication on 8716.

e. Reset 8716 to least sensitive range.

f. Reset attenuator to 17.2 dB. (10 + 7 +.2 dB).

g. Adjust R18 for full scale reading. Disconnect test setup.

6-9. TEMPERATURE OFFSET (REFER TO FIG. 6-2)

a. Zero meter on sensitive range with probe and meter at 25°C.

b. Remove calibration chart, if present, from handle.

c. Rotate handle (E) counterclockwise until set screw holes B, D line up with potentiometers R3 and R7. Potentiometer adjustment slots will be visible through the set screw holes. Potentiometer R4 will be properly aligned when R3 and R7 are in position.

DO NOT ROTATE HANDLE GREATER THAN ONE COMPLETE TURN
Excessive rotation may result in failure of cable wires

d. After adjustment, reverse procedure by rotating handle clockwise to its maximum clockwise position. Back-off up to 1/4 turn

until a screw treaded hole aligns with the (A) hole in the outer sleeve. Insert and securely fasten Phillips head screw.

e. Soak probe and meter for 1/2 hour at 55°C. Adjust R7 (see Figure 6-2) for a zero indication. Repeat 6-9a. and 6-9d.

6-10. ALARM CALIBRATION

a. Disconnect probe and connect the test set-up of Figure 6-3. Disconnect power supply (S1).

b. Set range switch on unit to low sensitivity (300%).

c. Set panel alarm control to 300 position. (Full clockwise).

d. Set attenuator for 10 dB. Close switch 1, and adjust power supply for a full scale indication of Model 8716.

e. Adjust R13 for an alarm threshold.

f. Open switch 1.

g. Set panel alarm potentiometer to mid position.

h. Close switch 1 and adjust attenuator threshold. Note that meter reads within range of 9 to 11. (0-20, white scale) Disconnect Test Setup. Return meter to case.

6-11. 8700 SERIES PROBE CALIBRATIONS

a. This section denotes the various pieces of equipment needed to calibrate 8700 series probes, and the procedures to perform calibrations. Sections 6-12 and 6-13 are for the Models 8741 and 8722 only. When calibrating other 8700 series probes, perform calibrations for their specified frequency range only.

b. Probe calibration required equipment.

	Noun	Manufacturer	Model No.
1.	Amplifier	Amplifier Research	10W1000
2.	Amplifier	Amplifier Research	50A15
3.	Amplifier	KELTEC	KUR630-200
4.	Amplifier	KELTEC	SR605-10
5.	Amplifier	SERVO	H979
6.	Amplifier	VARIAN	VZA-6902 L1
7.	Amplifier	VARIAN	VZK-6901 L1
8.	Attenuator	NARDA	765-30
9.	Attenuator	NARDA	757-10
10.	Attenuator	NARDA	777C-10
11.	Attenuator	NARDA	777C-20
12.	Directional Coupler	NARDA	3020A
13.	Directional Coupler	NARDA	3022
14.	Directional Coupler	NARDA	3024
15.	Directional Coupler	NARDA	5075

b. Probe Calibration, required test equipment (Cont'd)

	Noun	Manufacturer	Model No.
16.	Directional Coupler	NARDA	1067-10
17.	Directional Coupler	NARDA	1068-10
18.	Isolator	Sperry	D44L15
19.	Isolator	UTE	CT5155
20.	Power Meter	HP	438A
21.	Power Meter Head	HP	8481A
22.	Power Meter Head	HP	8486A
23.	Standard Gain Horn	NARDA	637
24.	Standard Gain Horn	NARDA	638
25.	Standard Gain Horn	NARDA	639
26.	Standard Gain Horn	NARDA	640
27.	Standard Gain Horn	NARDA	643
28.	Standard Gain Horn	NARDA	645
29.	Stub Tuner	MAURY	1878A
30.	Signal Generator (M.F)	H.P.	8350B
31.	Signal Generator (Plug in)	H.P.	83522A

b. Probe Calibration, required test equipment (Cont'd)

	Noun	Manufacturer	Model No.
32.	Signal Generator (Plug in)	H.P.	83572A
33.	Signal Generator (Plug in)	H.P.	86290C
34.	Signal Generator	H.P.	8656B
35.	TEM Cell	NARDA	8801
36.	Termination	BIRD	611
37.	Waveguide	NARDA	WR950 (Special Order)
38.	Waveguide Adapter	Sci. Atlanta	11-0.75 (2 each)
39.	Waveguide Adapter	NARDA	601A
40.	Waveguide Adapter	NARDA	609
41.	Waveguide Adapter	NARDA	613A
42.	Waveguide Adapter	NARDA	615

6-12. LOW FREQUENCY SENSITIVITY ADJUSTMENT (MODELS 8722, 8741 ONLY)

a. Set potentiometer R3 and R4 (see Figure 6-2) to their mid positions.

b. Determine an effective area A, of the TEM system shown in Figure 5. A is the ratio of the power density at the center work space of the TEM cell to the power indicated on the power meter, Pind. The effective area of the Narda 8801 TEM cell i A = (1630) a sq. sm. where a is the numeric attenuation of transmitted power (example: 30 dB=.001.)

$$Pd = \frac{Pind}{A}$$

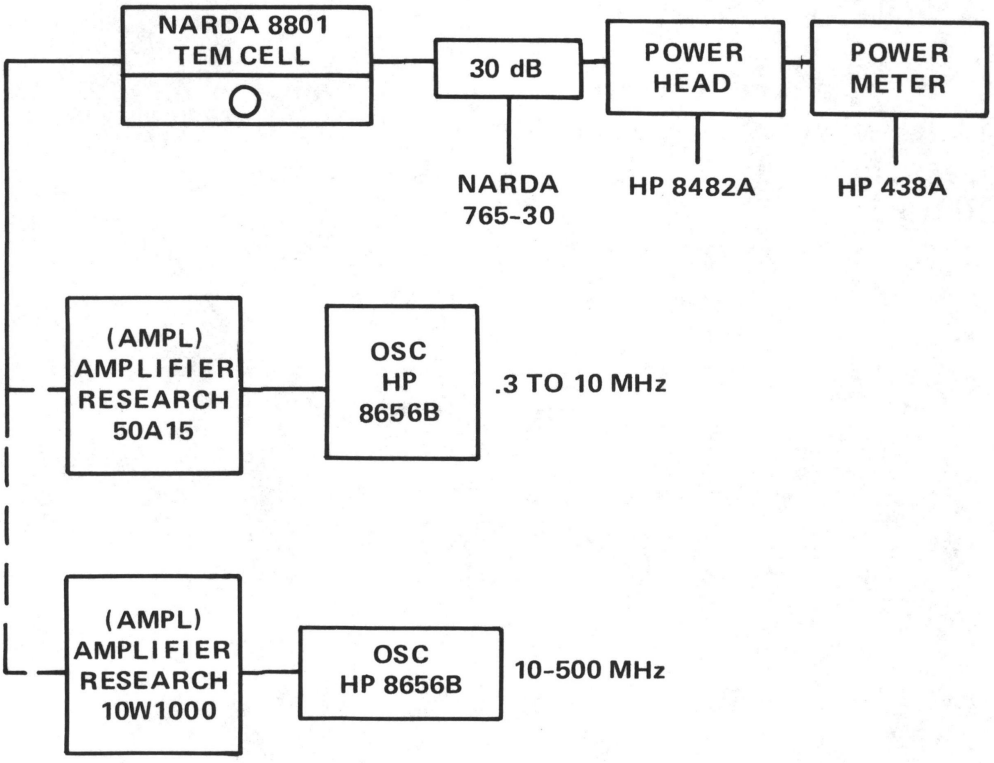


Figure 6-5. Low Frequency Sensitivity Adjustment Test Set-Up

c. Procedure: Position probe through sidewall of TEM cell such that the elements are in the mid position of the work space. Adjust power at 3 MHz for approx. a 10% exposure. Rotate probe to minimum indication position. Adjust power for an exact 10% exposure meter indication (1 mW/cm^2 for Model 8741) and record Pind. Rotate probe to maximum indicating position and record Pind. Record the mean of the two values and the mean power density equal to Pind/A.

d. Repeat procedure of 6-12c. at 30, 100 and 300 MHz.

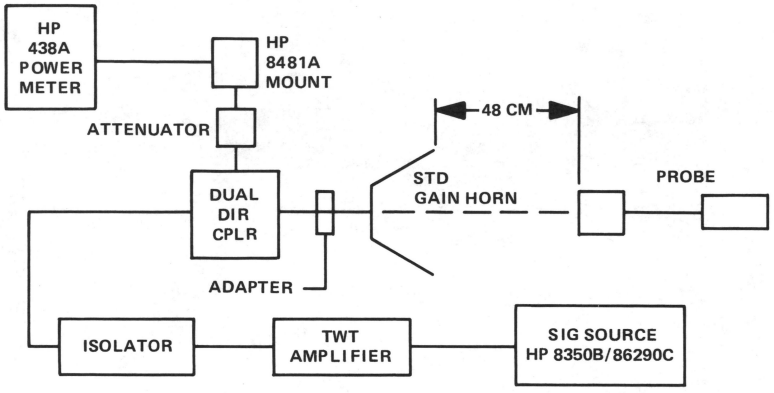
e. Record the power density at 3 MHz as PDL and highest value of 30 or 300 MHz and pdH. Solve the equation below to determine a multiplier.

$$M = \left[\frac{1.0}{PdL \times PdH} \right]^{1/2}$$

f. Multiply the Pd at 100 MHz by M. Establish that power density and adjust R3 (see Figure 6-2) for a meter indication of 10% exposure limit.

6-13. HIGH FREQUENCY SENSITIVITY ADJUSTMENT.

a. Standard gain horns are used to establish a calibration field 50 cm from horn aperture. Horn gain is corrected for near zone error. Test set up as in Figure 6-6.



			NARDA EQUIPMENT			
TEST FREQ	TWT AMPL	ISOLATOR	ADAPTOR	DIR CPLR	ATTENUATOR	STD GAIN HORN
8.2-11.0 GHz	SERVO H979	UTE CT5155	601A	5075	777C-20	640
1.7-2.6	KELTEC SR 605-10	SPERRY D44L15	615	3022	7776-10	645

Figure 6-6. High Frequency Sensitivity Adjustment Test Set-Up

b. Determine system effective area for each test frequency.

$$A = \frac{10{,}000\pi a}{G}$$

a = coupling factor and attenuation in decimal form.
G = gain corrected for near zone error.

c. Expose probe as in Figure 6-6 with handle along Poynting Vector, at 2.45 and 10 GHz.

(1) Apply power, rotate probe to the mean of the ellipse.

(2) Apply RF power until meter reads 10% exposure limit (1 mW/cm^2 for Model 8741). Record Pind. Calculate density Pd=Pind/A.

d. Assign PdL to the lowest value and PdH to the highest value. Determine a multiplier M

$$M = \left[\frac{.25}{PdL \times PdH}\right]^{1/2} \qquad M = \left[\frac{1}{PdL \times PdH}\right]^{1/2}$$

Model 8722 Model 8741

e. Multiply the Pd at 10 GHz by M. Establish that power density and adjust R3 for a meter indication of 10% exposure limit for Model 8722. Adjust for 1 mW/cm^2 for Model 8741.

6-14. FREQUENCY RESPONSE FOR MODEL 8722

a. Purpose of this test is to prove that the frequency response conforms to the ANSI C95.1-1982 RFPG at the meter indication of 10% of exposure limit ± 2 dB. Due to the high levels required testing will be done at the 10% exposure limit. Probe will be illuminated by a field whole level will be adjusted until the meter reads 10% of exposure limit. The magnitude of this field will be determined and compared to the Table of Limits, see Table 1. Three procedures will be utilized. For 300 MHz and below, fields will be generated in a TEM cell. At 750 MHz, and 1000 MHz calibration will be in a WR975 waveguide. For frequency from 1700 to 40 GHz, calibration fields are established with standard gain horns.

6-15. PROBE CALIBRATION .3 through 300 MHz (Models 8731, 8733, 8752, 8754, 8760, 8761, 8762)

a. Determine an effective area A, of the TEM system shown in Figure 6-7. A is the ratio of the power density at center work space of the TEM cell to the power indicated on the power meter, Pind. The effective area of the Narda 8801 TEM cell is A = (1630) a square cm where a is the numeric attenuation of transmitted power (example: 30 dB = .001).

$$Pd = \frac{Pind}{A}$$

$$Pd = \frac{Pind}{A}$$

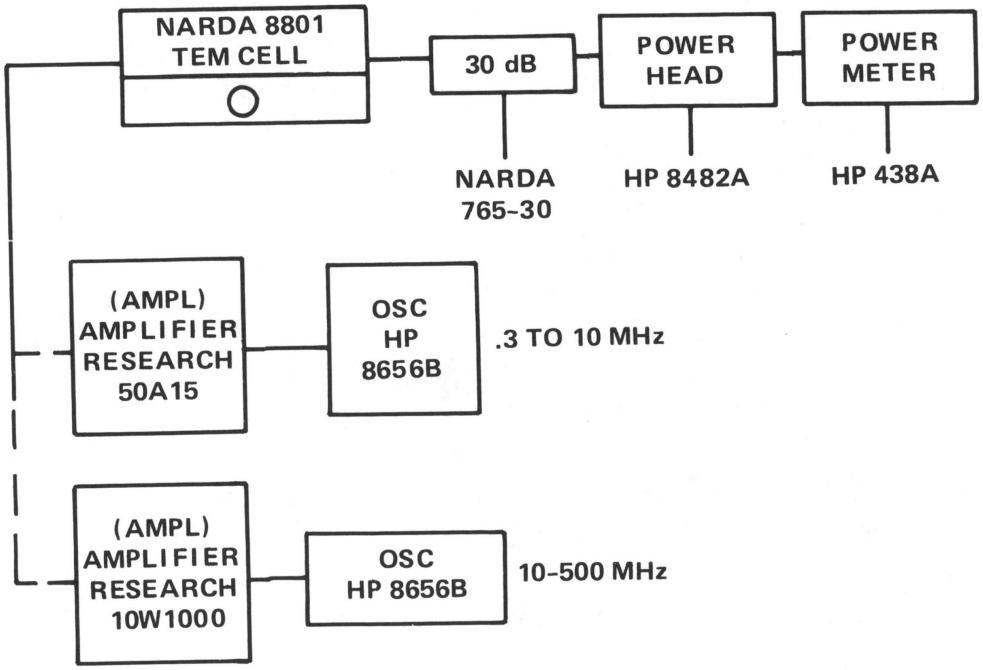


Figure 6-7. Low Frequency Probe Calibration Test Set-Up for 0.3 to 500 MHz

"A" is also equal to the power indicated for a power density of 1 mW/sq. cm.

The calculation of power density, Pd, in the TEM cell in milliwatts/sq. cm.

$$Pd = \left[\frac{E^2}{d}\right] \qquad 3770 = \frac{E^2}{84.8}$$

where d is the distance from the septum to the top of bottom wall in meters. d for the Narda 8801 is .15 meters. E is the potential on the septum in volts. The power transmitted down the cell is

$$P_T = E^2/52$$

52 is the true impedance of the cell in the work space. The power indicated in mW. Pind = 1000 PTa

$$A = \text{Pind at 1 mW/cm}^2 = 1000\alpha P_T \; a = 1000$$

$$\frac{E^2}{52} = 1630 \; a$$

b. Procedure: Position probe through sidewall of TEM cell such that the elements are in mid position of the work space. Adjust power at .3 MHz for approximately a 10% exposure. Rotate probe to minimum indicating position. Adjust power for an exact 10% exposure meter indication and record Pind. Rotate probe to maximum indicating position and record Pind. The ratio of these two readings should be less than 1.5 dB.

c. Rotate probe to the mean of the two values and adjust power density to exact 10% exposure. Record Pd = Pind/A.

d. Repeat procedure of 6-15b. at 3, 10, 30, 100 and 300 MHz.

6-16. PROBE CALIBRATIONS AT 750 MHz AND 1000 MHz (Models 8721, 8723, 8741, 8722, 8760, 8761, 8762).

a. Test set up is as in Figure 6-8. Tuner is adjusted at each frequency for minimum standing wave. The slide is positioned for calibration at the mean position of the remaining standing wave.

b. Determine the effective area A at 750 and 1000 MHz. Effective area of waveguide WR975 is the ratio of the power indicated to the power density at the center of the waveguide. It is also equal to the power indicated for a power density of 1 mW/cm. It is derived in the following manner.

The wave impedance

$$Z_W = \frac{Zo}{\sqrt{1-(\lambda o/2a)^2}}$$

Where a is the larger dimension of the guide, o is the wavelength at the frequency of operation, Zo is the free space impedance of 377Ω. At the center of the guide

$$Ey = \left[\frac{4Z_W P_Z}{a^2}\right]^{1/2}, \quad Hx = \left[\frac{4P_Z}{Z_W a^2}\right]^{1/2}$$

P_Z is the power transmitted down the guide.

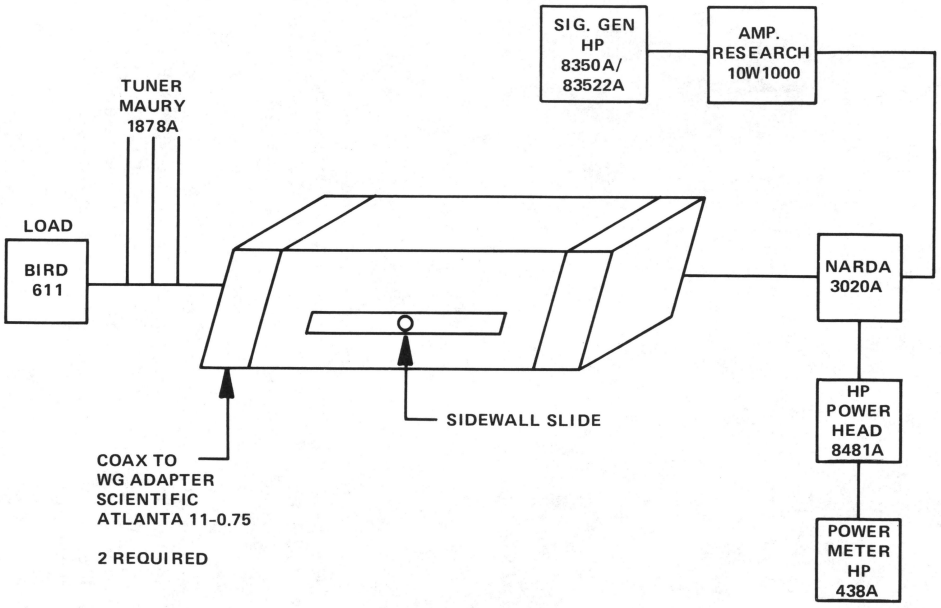


Figure 6-8. Probe Calibration Test Set-Up for 750 MHz to 1.1 GHz

The equivalent power density at the center of the guide is:

$$P_d = \left[\frac{4P_z}{a^2}\right]\left[\frac{Z_w}{Z_o}\right] = \left[\frac{4P_z}{a^2}\right]\left[1 - \frac{(\lambda)}{2a}^2\right]^{1/2}$$

$$P_{ind} = \alpha P_z = \alpha \frac{P_d}{4} a^2 \left[1 - \frac{(\lambda)}{2a}^2\right]^{1/2}$$

at 1mW/cm^2,

$$P_{ind} = A \quad A_{750} = 90.2\ (a)\ cm^2$$

$$A_{1000} = 122\ (a)\ cm^2$$

c. Insert probe through narrow wall and position elements at mid position of guide. Apply RF power at 750 MHz and rotate probe to a mean position of ellipse ratio. Note ellipse ratio to be less than 1.5 dB.

d. Ellipse ratio is the ratio of the maximum to minimum readings as the probe is rotated about its axis. The mean position is position of the probe that produces a reading equal to the average of the maximum and minimum readings.

e. Reset frequency to 1000 MHz and adjust tuner for minimum standing wave. Position slide at mean of remaining standing wave. Insert probe through narrow wall position probe at mid position of waveguide. Apply RF power and rotate probe to mean position of the ellipse ratio. Note ratio to be 1.5 dB.

Adjust power for an exact 10% Exposure Limit indication. Record Pind and

$$Pd = \frac{Pind}{A_{1000}}$$

Compare P_d with table limits.

6-17. PROBE CALIBRATION 1.7 to 40 GHz.

a. Standard gain horns are used to establish a calibration field 50 cm from horn aperture. Horn gain is corrected for near zone error. Test set up is as in Figure 6-9.

b. Determine system effective area A for each test frequency.

A is the ratio of the power indicated to the power density at 50 cm from the horn aperture. It is also equal to the power indicated for a power density of 1 mW/cm^2 at 50 cm from the horn aperture.

$$Pind = aP_T = \frac{a4\pi\, d^2 P_d}{G}$$

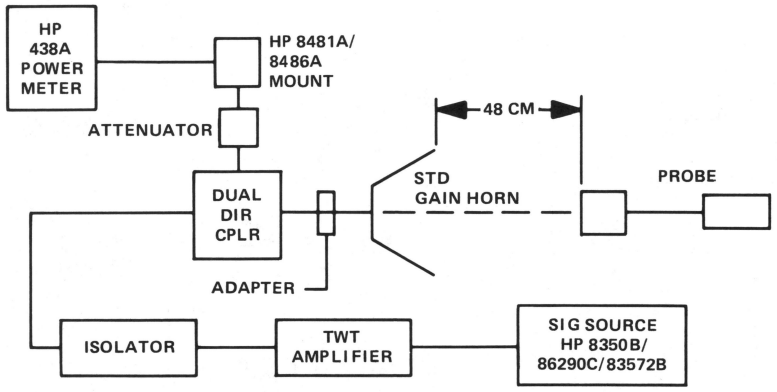


Figure 6-9. High Frequency Probe Calibration
Test Set-Up for 1.7 to 40 GHz

TEST FREQ	TWT AMPL OR SIG GEN	ISOLATOR	NARDA EQUIPMENT			
			ADAPTER	DIR CPLR	ATTENUATOR	STD GAIN HORN
1.7-2.45 GHz	KELTEC SR 605-10	SPERRY D44L15	615	3022	777C-10	645
8.2-10.0 GHz	SERVO H979	UTE CT5155	601A	5075	777C-20	640
18 GHz	KELTEC KUR 630-200	—	—	1068-10	—	638
26 GHz	VARIAN VZK 6901L1	—	—	1067-10	—	637
40 GHz	VARIAN VZA 6902L1	—	—	1067-10	—	637

Figure 6-9. High Frequency Probe Calibration Test Set-Up for 1.7 to 40 GHz

Where P_T is the power transmitted in milliwatts

P_d = power density, 1 mW/cm squared

d = distance from aperture = 50 cm

= coupling factor and attenuation between P indicated frequencies is listed in the Table below:

a = coupling factor and attenuation in decimal (i.e. 10 dB = .1, 20 dB = .01)

G = gain corrected for near zone error (numeric)

c. Expose probe as in Figure 6-9 with handle along Poynting Vector. At each frequency:

(1) Apply power, rotate probe to mean of ellipse. Note ellipse ratio is less than 1.5 dB.

(2) Apply RF power until meter reads 10% exposure limit. Record Pind and power density. P_d = Pind/A.

(3) Note that Pd at each frequency meets the limits of Table 6-1.

Near Zone Gain at 50 cm

Freq. GHz	NARDA Horn Model	Gain DB	Gain Numeric	Transmitter Power Level (Watts)		
				1 mW/cm^2	5 mW/cm^2	100 mW/cm^2
1.7	645	12.43	22.03	1.42	7.13	142.6
2.45	645	15.28	33.73	.931	4.65	93.13
4.0	643	14.4	27.54	1.14	5.70	114
8.2	640	14.4	27.54	1.14	5.70	114
10.0	640	15.74	37.50	.837	4.18	83.77
18.0	638	14.65	29.17	1.077	5.38	107.69
26.5	637	14.5	28.2	1.144	5.57	111.4
40.0	637	17.7	58.9	.534	2.66	53.33

6-18. CALIBRATION FACTORS FOR MODEL 8722

a. Calculate calibration factors by dividing the power density for a mid scale indication (i.e. 10%) by the design center value of Table 6-1.

Table 6-1

10% of Exposure Limit and Required Tolerance

Frequency	mW/cm^2 Design Center	mW/cm^2 Max. Min.
2 MHz	10.0 mW/cm^2	15.8-6.31
3 MHz	10.0 mW/cm^2	15.8-6.31
10 MHz	0.9	1.42-.57
30 MHz	0.1 mW/cm^2	.158-.063
100 MHz	0.1	.158-.063
300 MHz	0.1	.158-.063
750 MHz	0.250	.395-.158
1000	0.333	.521-.209
1700 MHz through 40 GHz	0.5	.79-.316
	0.5	.79-.316

6-19. FREQUENCY RESPONSE FOR MODEL 8741

a. Follow the procedure of 6-15 through 6-17 except that Meter indications and test power density is 1 mW/cm^2.

6-20. CALIBRATION FACTORS FOR MODELS 8721, 8731, 8741, 8761

a. Calibration factors for Model 87X1 probes are the recorded Pd values divided by 1mW/cm^2 expressed decimally.

6-21. CALIBRATION FACTORS FOR MODELS 8723, 8733

a. Follow the procedures of 6-15 (to 300 MHz) for Model 8733 and para. 6-15 through 6-17 for Model 8723, except that meter indications and test power density is 5 mW/cm^2.

b. Calibration factors for Model 87X3 probes are the recorded Pd values divided by 5 mW/cm^2, expressed decimally.

6-22. CALIBRATION FACTORS FOR MODELS 8752, 8762

a. Follow the procedures of 6-15 (to 10 MHz) for Model 8752 and para. 6-15 and 6-16 for Model 8762, except that meter indications and test power density is 10 mW/cm^2.

b. Calibration factors for 87X2 probes are the recorded values divided by 10 mW/cm^2, expressed decimally.

6-23. CALIBRATION FACTORS FOR MODEL 8754

a. Follow the procedures of para. 6-15 (to 10 MHz) except that meter indications and test power density is 100 mW/cm^2.

b. Calibration factors for 8754 are the recorded values divided by 100 mW/cm^2, expressed decimally.

6-24. CALIBRATION FACTORS FOR MODEL 8760

a. Follow the procedures of para. 6-15 and 6-16, except that meter indications and test power density is 1 $\mu W/cm^2$.

b. Calibration factors for 8760 are the recorded values divided by 1 $\mu W/cm^2$, expressed decimally.

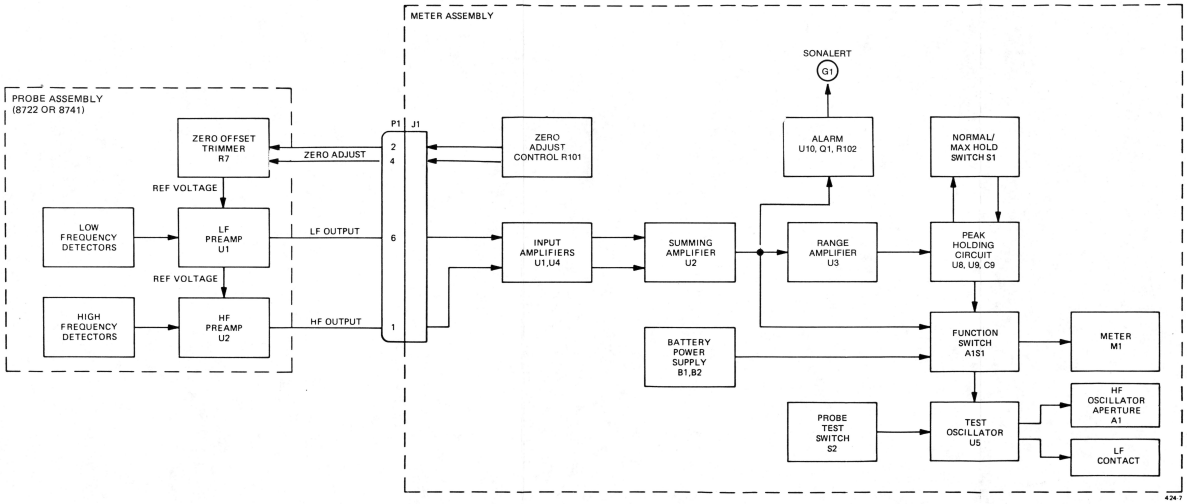
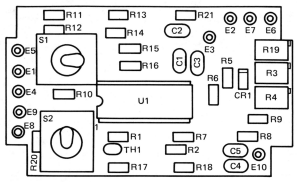


Figure 6-10. Model 8700 Radio Frequency Test Set Functional Block Diagram, Utilizing Model 8716 Meter



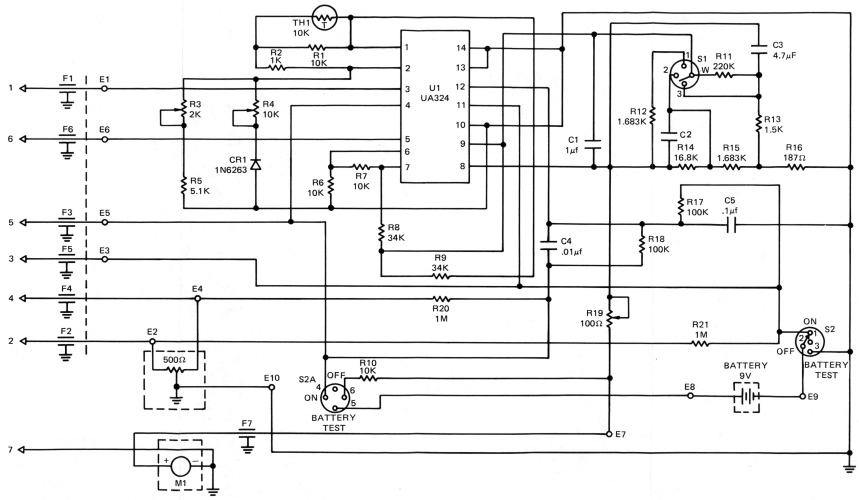
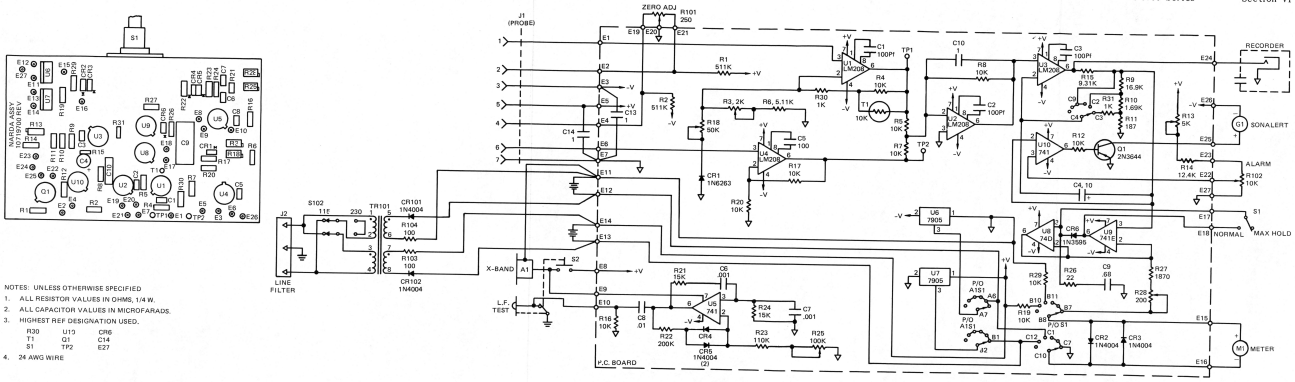


Figure 6-11. Model 8711 Schematic and PC Board Layout


ZERO ADJ
R101
250
J1
(PROBE)
RECORDER
SONALERT
ALARM
R102
10K
NORMAL
MAX HOLD
METER
S1
S2
J2
LINE
FILTER
S102
TR101
CR101
1N4004
CR102
1N4004
X-BAND
L.F.
TEST
P.C. BOARD
TP1
TP2
R1 511K
R2 511K
R3 2K
R4 10K
R5 10K
R6 5.11K
R7 10K
R8 10K
R9 16.9K
R10 1.69K
R11 187
R12 10K
R13 5K
R14 12.4K
R15 9.31K
R17 10K
R18 50K
R20 10K
R21 15K
R22 200K
R23 110K
R24 15K
R25 100K
R26 22
R27 1870
R28 200
R29 10K
R30 1K
R31 1K
R103 100
R104 100
R105 100
R106 100
R107 100
R108 100
R109 100
R110 100
R111 100
R112 100
R113 100
R114 100
R115 100
R116 100
R117 100
R118 100
R119 100
R120 100
R121 100
R122 100

SECTION VII

PREPARATION FOR RESHIPMENT

7-1. INTRODUCTION. This section contains procedures for preparing the test set for shipment.

7-2. PROCEDURES. To prepare the test set for shipment perform the procedures contained in the following subparagraphs:

a. Disconnect connector P1 of probe assembly from a PROBE connector J1 of meter assembly.

b. Stow meter assembly, probe assembly, shoulder strap and manual in the carrying case.

c. Wrap the carrying case in moisture proof paper or plastic film and securely tape the wrapping.

d. Place the wrapped package into a suitable cardboard container with at least three inches of foam padding all around.

e. Securely tape the container.

f. Mark the container in accordance with applicable regulations.

SECTION VIII

STORAGE

8-1. INTRODUCTION. This section contains information for storing the test set. For short-term storage, the components of the test set should be stowed in the carrying case. For long-term storage, refer to Figure 5-1 and prepare the test set in accordance with the following procedure:

CAUTION

Do not place the test set, operating or non-operating, in an area where fields are expected to exceed a 300% reading as damage to the test set may result.

a. On meter assembly, loosen four captive screws (5) and remove cover (4).

b. Carefully remove two batteries (3) and disconnect battery connections (2).

c. Replace battery connectors (2) in battery compartment of meter assembly.

d. Replace cover (4) and fasten with four captive screws (5).

e. Disconnect connector P1 of probe assembly from PROBE connector J1 of meter assembly.

f. Stow meter assembly, probe assembly, shoulder strap, manual and batteries in carrying case.

g. Store test set in a clean, dry area.

SECTION IX

PARTS LIST

9-1. INTRODUCTION. This section contains information for ordering replacement parts for the test set. This information includes a listing of the manufacturer's codes and a replacement parts list. The following paragraphs describe the lists and their application.

9-2. MANUFACTURER'S CODES. To identify the manufacturer of a test set part, a manufacturer's code is given in the DESCRIPTION column of the parts list, enclosed in parentheses. The manufacturer's code used to identify the manufacturer is in accordance with Handbook H4-1 and H4-2. Table 9-1 contains a listing of the manufacturer's codes used in the replacement parts list and gives the name and address of the manufacturer.

9-3. REPLACEABLE MAJOR ASSEMBLIES LIST. Table 9-2 contains a listing of replaceable major assemblies. To locate the part in the equipment, refer to the figure number to identify the illustration showing the part. Use the index number to identify the location of the part on the illustration.

9-4. REPLACEABLE PARTS LIST. Tables 9-3 through 9-5 contain a listing of the replaceable parts for Models 8711, 8716, 8721, and 8722. Parts are listed in alpha-numerical order by reference designator. Complete descriptions of each component are provided in addition to the manufacturer's code and Narda part number to facilitate ordering.

Table 9-1

Manufacturer's Codes

Manufacturer's Supply Code	Name	Address
01121	Allen Bradley Co.	El Paso, TX
01295	Texas Instruments, Inc.	Dallas, TX
04713	Motorola Semiconductor	Phoenix, AZ
05245	Corcom	Chicago, IL
31433	Union Carbide	Greenville, SC
13715	Fairchild	San Rafael, CA
12697	Clarostat Manufacturing Co., Inc.	Dover, NH
28480	Hewlett Packard	Palo Alto, CA
30983	Mepco/Electra	San Diego, CA
56289	Sprague	North Adams, MA
80294	Bourns, Inc.	Riverside, CA
95275	Vitramon, Inc.	Bridgeport, CT
99899	Narda Microwave Corp.	Hauppauge, NY

Table 9-1 (Cont)

Manufacturer's Supply Code	Name	Address
91637	Dale Electronics	Norfolk, NE
93790	Cornell Dublier	New Bedford, MA
13511	Amphenol	Las Gatos, CA
09353	C&K Components	Newton, MA
80112	G.C. Electronics	Los Angeles, CA
05010	Gulton	Metuchen, NJ

Table 9-2

Radio Frequency Radiation Test Set
Replaceable Major Assemblies

Figure and Index No.	Part Number	Description	Quantity Used
1-1-1	10666808	Carrying Case (99899)	1
1-1-2	99902000	Shoulder Strap (99899)	1
1-1-3	87XX	Probe Assembly, Model 87XX (99899)	1
1-1-4	8716	Meter Assembly, Model 8716 (99899)	1
5-1-3	88018000	Battery, 8.4V, NiCad (99899)	2
5-1-1	93035000	Knob (99899) Range Switch	1

Table 9-3

Model 8711 Repair Replaceable Parts List

Ref. Des.	Description	Mfg. Code	Mfg. Part Number	NARDA Part No.
B1	Battery, 9V	31433	216	88009000
C1	Capacitor, 1 fd	56289	5C023105X0250B3	80139105
C2	See C1			
C3	Capacitor, 4.7 fd	56289	196D475X9010HA1	80230020
C4	Capacitor, .01 fd	56289	CK05BX103K	80187000
C5	Capacitor, .1 fd	56289	CK05BX104K	80187005
CR1	Diode	28480	1N6263	84585004
J1	Connector	13511	703-91-7-3475-1	81851000
M1	Meter	99899		82557000
R1	Resistor, 10K , 5%, 1/8W	01121	RC05GF103T	83164087
R2	Resistor, 1K , 5%, 1/8W	01121	RC05GF102T	83164064
R3	Potentiometer, 2K	80294	3262-1-202	83306026
R4	Potentiometer, 10K	80294	3262-1-103	83306028
R5	Resistor, 5.1K , 5%, 1/8W	01121	RC05GF512T	83164080
R6	Resistor, 10K , 1%, 1/8W	91637	RN55D1002F	83049288
R7	See R6			

Table 9-3 (Cont)

Ref. Des.	Description	Mfg. Code	Mfg. Part Number	NARDA Part No.
R8	Resistor, 34K , 1%, 1/8W	91637	RN55D3402F	83049338
R9	See R8			
R10	See R1			
R11	Resistor, 220K , 5%, 1/8W	01121	RC05GF224T	83164119
R12	Resistor, 1.69K , 1%, 1/8W	91637	RN55D1691F	83049214
R13	Resistor, 1.5K , 1%, 1/8W	91637	RN55D1501F	83049209
R14	Resistor, 1.68K , 1%, 1/8W	91637	RN55D1681F	83049
R15	See R12			
R16	Resistor, 187 , 1%, 1/8W	91637	RN55D1870F	83170009
R17	Resistor, 100K , 5%, 1/8W	01121	RC05GF104T	83164111
R18	See R17			
R19	Potentiometer, 100	80294	3262-1-101	83306022
R20	Resistor, 1.8M , 5%, 1/8W	01121	RC05GF105T	83164141
R21	See R20			
R101	Potentiometer, 500	80294	84C1D-E16-J08	83266004
S1	Switch, 1P3T	27191	T01-232	83767000
S2	Switch, 2P3T	27191	T01-231	83768000
TH1	Thermistor, 10K	05010	41TD4A	83272005
U1	Integrated Circuit	13715	UA324	84879000

Table 9-4

Model 8716 Repair Replaceable Parts List

Ref. Des.	Description	Mfg. Code	Mfg. Part Number	NARDA Part No.
A1	Oscillator	99899		87304000
B1,B2	Battery, 8.4V, 250 man.	99899		88018000
C1	Capacitor, 100 pf	95275	CK05BX101K	80187019
C2	See C1			
C3	See C1			
C4	Capacitor 10 fd 25V	31433	T368B106M025AS	80198010
C5	See C1			
C6	Capacitor, .001 f	95275	CK05BX102K	80187031
C7	See C6			
C8	Capacitor, .01 f	95275	CK05BX103K	80187000
C9	Capacitor, .68 f	84411	X463UW.68MFD	80221000
C10	Capacitor, 1 fd	56289	5C023105X0250B3	80139105
C11,C12	Not Used			
C13	See C10			
C14	See C10			

Table 9-4 (Cont)

Ref. Des.	Description	Mfg. Code	Mfg. Part Number	NARDA Part No.
CR1	Diode, 1N6263	28480	1N6263	84585004
CR2	Diode, 1N4004	01295	1N4004	84568004
CR3	See CR2			
CR4	See CR2			
CR5	See CR2			
CR6	Diode, IN3595	04713	1N3595	84704000
CR101	See CR2			
CR102	See CR2			
G1	Son. Alert Assy	99899		306934
J1	Connector	13511	703-91-7-3475-1	81851000
J2	Recorder Assy	99899		306948
M1	Meter	99899		82552000
Q1	Transistor 2N3644	13715	2N3644	89018010
R1	Resistor, 511K , 1/8W, 1%	91637	RN55D2213F	83049451
R2	See R1			
R3	Resistor, Potent. 2K	80294	RJ26FX202	83234123
R4	Resistor, 10K	91637	RN55D1002F	83049288
R5	See R4			

Table 9-4 (Cont)

Ref. Des.	Description	Mfg. Code	Mfg. Part Number	NARDA Part No.
R6	Resistor, 5.11K	91637	RN55D5111F	83049260
R7	See R4			
R8	See R4			
R9	Resistor, 16.9K	91637	RN55D1692F	83049310
R10	Resistor, 1.69K	91637	RN55D1.691F	83049268
R11	Resistor, 187	91637	RN55D1870F	83049123
R12	See R4			
R13	Resistor, Potent. 5K	80294	RJ26FX502	83234124
R14	Resistor, 12.4K	91637	RN55D1242F	83049297
R15	Resistor, 9.31K	91637	RN55D9311F	83049285
R16	See R4			
R17	See R4			
R18	Resistor Potent. 50K	80294	RJ26FX503	83234128
R19	See R4			
R20	See R4			
R21	Resistor, 15K	91637	RN55D1502F	83049305
R22	Resistor, 200K	91637	RN55D2003F	83049412
R23	Resistor, 110K	91637	RN55D1103F	83049387

Table 9-4 (Cont)

Ref. Des.	Description	Mfg. Code	Mfg. Part Number	NARDA Part No.
R24	See R21			
R25	Resistor, Potent. 100K	80294	RJ20FX104	83234129
R26	Resistor, 22	11211	RCR07G220JS	83226022
R27	Resistor, 1.87K	91637	RN55D1871F	83049218
R28	Resistor, Potent. 200	80294	RJ26FX201	83234120
R29	See R4			
R30	Resistor, 1K	91637	RN551001F	83049192
R31	See R30			
R101	Resistor, Potent. 250	80294	84C1D-E20-J07	83266005
R102	Resistor, Potent. 10K	99899	8312301824	83123024
R103	Resistor, 100 , 1/2W			
R104	See R103			
S1	Switch	99899		83754000
S101	Switch	09353	7101SCW2Q	83530000
S102	Switch	09353	35-420	83746000
T1	Thermistor 10K	05010	41TD4A	83272005
TR101	Transformer			

Table 9-4 (Cont)

Ref. Des.	Description	Mfg. Code	Mfg. Part Number	NARDA Part No.
U1	Integrated Circuit	13715	LM208AH	84728000
U2	See U1			
U3	See U1			
U4	See U1			
U5	Integrated Circuit	13715,	UA741	84548000
U6	Integrated Circuit	07263	7905	84902000
U7	See U6			
U8	Integrated Circuit	07263	UA740C	84705000
U9	Integrated Circuit	07263	UA741E	84727000
U10	See U5			

Table 9-5

8741/8722 Repair Replaceable Parts List

Ref. Des.	Description	Mfg. Code	Mfg. Part Number	NARDA Part No.
C1	Capacitor, .01 f, ±20%, 25 VDC	56289	490P1030R25	80296000
C2	See C1			
C3	See C1			
C4	See C1			
C5	See C1			
C6	See C1			
C7	See C1			
C8	See C1			
P1	Connector	13511	703-91-T-3475-1	81850000
R1*	Resistor, 100 , 1/8W, 1%	91637	RN55D10000F	83049097
R1**	Resistor, 1K , 1/8W, 1%	91637	RN55D1001F	83049192
R2	See R1			
R3*	Resistor, Potent. 1K	80294	3262W-1-102	83190007
R3**	Resistor, Potent. 2K	80294	3262W-1-202	83190026
R4	See R3			

Table 9-5 (Cont)

Ref. Des.	Description	Mfg. Code	Mfg. Part Number	NARDA Part No.
R5**	Resistor, 75K , 1/8W, 1%	91637	RN55D7502F	83049371
R5*	Resistor, 10K , 1/8W, 1%	91637	RN55D1002F	83049285
R6	Resistor, 100K , 1/8W, 1%	91637	RN55D1003F	80349383
R7	Resistor, Potent. 10K	80294	3262W-1-203	83190029
R8	Resistor, 10M , 1/8W, 5%	01121	RC05GF106T	83164159
TH1	Thermistor, 5K	05010	35TD4A	83272000
TH2	See TH1			
U1	Integrated Circuit	07263	1CL7605CJN	84891000
U2	See U1			

*Used on Model 8741 Only
**Used on Model 8722 Only